Diagnostic yield of baseline and follow-up PET/CT studies in ablative therapy for non-small cell lung cancer☆

J.L. Pou Ucha a, *, J.M. Nogueiras Alonso b, A.M. Alvarez Paez a, B.A. Suarez Arfenoni c, A. Serena Puig a, A.M. Lopez Lopez b, J. Barandela Salgado a, L.M. Campos Villarino a, M. Casal Rivas d, R. Guitian Iglesias b

a Unidad de Medicina Nuclear, Complejo Hospitalario Universitario de Vigo, Vigo, Spain
b Unidad de Medicina Nuclear, Galaria, Vigo, Spain
c Unidad de Radiodiagnóstico, Complejo Hospitalario Universitario de Vigo, Vigo, Spain
d Unidad de Radiología Intervencionista, Complejo Hospitalario Universitario de Vigo, Vigo, Spain

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A B S T R A C T

Although they have proven effectiveness, radiofrequency and microwave ablation techniques have a high rate of partial responses. Diagnostic studies that anticipate the changes in morphology are essential for earlier detection of residual viable tumor tissue or local recurrences to identify patients who will benefit from a new treatment. Our study has determined the diagnostic yield of PET/CT studies at baseline and follow-up and adequate time between them and the ablation intervention. Seven patients with single tumor lesion with a total of 8 ablations were included. CT and PET/CT studies were performed at baseline and follow-up after ablation. Average times between PET studies at baseline and follow-up and the ablative therapy were 1.8 and 3.4 months, respectively. Mean scores in metabolic activities of the PET at baseline and follow-up were 7.6 and 4.3 g/ml of SUVmax, respectively. The Dual Time Point technique helped to identify viable tissue after ablation in 3 cases. Follow-up PET/CT studies have conditioned the various treatment strategies adopted by clinical oncologists. The high yield of the PET/CT study including the Dual Time Point technique may be considered as a study replacement of initial and follow-up contrast-enhanced CT before and after treatment with RFA and AMO, this achieving considerable reduction in the exposure to high radiation levels. We propose conducting the first PET/CT follow-up study at 3 months of the RFA and AMO.

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R e s u m e n

Aunque con efectividad probada, las técnicas de ablación por radiofrecuencia y microondas presentan un elevado índice de respuestas parciales. Es imprescindible contar con estudios diagnósticos que se anticipen a los cambios morfológicos para una detección más temprana del tejido tumoral residual viable o de recurrencias locales para determinar los pacientes que serán beneficiados de un nuevo tratamiento. Determinamos mediante nuestro estudio la rentabilidad diagnóstica de los estudios de PET/CT basal y de seguimiento y el tiempo adecuado entre estos y la intervención por ablación. Incluimos 7 pacientes con lesión tumoral única con un total de 8 ablations. Hemos realizado estudios CT y PET/CT basales y de seguimiento tras ablación. Los tiempos medios entre estudios PET basales y de seguimiento y la terapia ablativa fueron 1,8 y 3,4 meses respectivamente. Las cuentas medias en actividades metabólicas de los PET basales y de seguimiento han sido de 7,6 y 4,3 g/ml de SUVmax respectivamente. La técnica de Dual Time Point ayudó en 3 casos a identificar tejido viable tras ablación. Los estudios de seguimiento PET/CT han condicionado las diversas estrategias terapéuticas adoptadas por los oncólogos clínicos. El alto rendimiento del estudio PET/CT incluyendo la técnica de Dual Time Point puede plantearse como estudio de sustitución de los CT con CIV basales y de seguimiento previo y posterior al tratamiento con RFA o AMO logrando reducir de manera considerable la exposición a altas cifras de radiación. Proponemos realizar el primer estudio PET/TC de seguimiento a 3 meses de realizada la ARF o AMO.

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temperatures greater than 90 °C, thereby inducing thermal coagulative necrosis of the lesion and the surrounding normal pulmonary tissue forming ablation margins.2

Although good results have been achieved in the ablation of hepatic lesions, these techniques are increasingly used as an effective alternative treatment in patients with early stage and inoperable lung cancer as well as in advanced stages of the disease.3 Ablation of stage I non-small cell lung cancer (NSCLC) has an annual survival rate of 78% and a 5-year survival rate of 27% compared with a 50% 1-year survival in patients under observation without treatment.4

Despite the elevated 1-year survival rate of ablation, there is also an elevated index of residual tumor persistence at the intervention site. Diagnostic studies able to anticipate the morphologic changes observed in the computerized tomography (CT) studies are essential for earlier detection of viable residual tumor tissue with the aim of helping to determine which patients may benefit from repetition of ablation or another treatment such as radiotherapy.4

The use of CT with intravenous contrast (IVC) is currently the technique of choice for the control of ablation. The typical morphologic found is a cystic lesion with a liquid–air component within a wall of different thickness enhanced by IVC. An increase in lesion size of enhancement with IVC are findings of abnormality, although they are not specific for malignancy and may also be found in cases of inflammatory reaction. Morphological variations are difficult to interpret, with the area of ablation being greater than the nodule treated and the size slowly decreases over time. Thus, incomplete treatment is generally discovered during the 6 months after RFA.

Metabolic imaging studies with positron emission tomography (PET) using the radiotracer 18F-fluorodeoxyglucose (FDG) have shown promising results. The advantage of these studies is fundamentally justified by the metabolic differences perceived prior to the morphological changes of the tumor lesion.

Despite the greater diagnostic yield obtained, the first PET/CT control study after ablation has yet to be performed. The limitations of PET as a follow up test include low spatial resolution and the frequent presence of circumferential FDG uptake in the immediate follow up study, reflecting the inflammatory reaction surrounding the tumor treated by ablation. This peripheral uptake may represent a viable residual or recurrent tumor foci or even intense inflammatory response. The differentiation of these interpretations is currently a great challenge.

We determined the diagnostic yield of baseline PET/CT and the appropriate time between intervention by RFA or MWA and the follow up PET/CT study after treatment.

**Material and methods**

**Patients**

Patient inclusion in this procedure was approved by the Scientific Committee of the Complejo Hospital-Universitario de Vigo and all the patients provided written informed consent for inclusion in the study. Patient inclusion and exclusion criteria are shown in **Table 1**. Patients with pulmonary lesions considered as good candidates for ablative therapy were prospectively evaluated in our center over a 2-year period from February 2009 to February 2011. The study included 7 patients with a total of 8 ablations (7 men with a mean age of 72 years) with a history of NSCLC (6 adenocarcinoma, 1 epidermoid carcinoma). Six out of 7 patients (86%) underwent 1 procedure with ablation while 1/7 (14%) underwent 2 procedures. This latter patient was considered as 2 baseline PET/CT and 2 follow up PET/CT.

### Table 1

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non operable tumors</td>
<td>Non correctable coagulopathy</td>
</tr>
<tr>
<td>Primary or secondary lung tumors</td>
<td></td>
</tr>
<tr>
<td>- Non-small cell stage IB &lt; 40 mm</td>
<td></td>
</tr>
<tr>
<td>- Metastasis:</td>
<td></td>
</tr>
<tr>
<td>a) with controlled primary cancer,</td>
<td></td>
</tr>
<tr>
<td>b) exclusion of other metastases,</td>
<td></td>
</tr>
<tr>
<td>c) up to 3 pulmonary nodules &lt; 30 mm</td>
<td></td>
</tr>
<tr>
<td>Histological demonstration or radiological evidence of new lesion or growth</td>
<td></td>
</tr>
</tbody>
</table>

**Ablation by radiofrequency and by microwaves**

The procedures were carried out by an interventional radiologist (M.C., 21 years of experience) using the Cool-tip™ RF Ablation System COVIDEN needle 17G × 150 mm (radiofrequency needle), the Evident™ MWA Percutaneous Antenna COVIDEN 17G × 150 mm (microwave needle) and the Amica probe 16G × 150 mm HS Hospital Service SPA (microwave needle). All the procedures were performed with 30 mm of diameter of ablation. After induction of general anesthesia, the patients underwent serial CT studies for the correct placement of the electrodes and to control the effect of the treatment, being monitored every 3 minutes with CT to detect possible complications. On termination of the ablation procedure a control CT was carried out with the aim of detecting pneumothorax.

**PET/CT**

All the metabolic imaging studies were performed with the same PET/CT equipment (GE HealthCare, Discovery LS16 model PET/CT, workstation Advantage v4.4). The same number of emission and transmission studies was performed. The patients had fasted for more than 4 h prior to the PET/CT FDG study. All patients with glycemia >200 mg/dl did not undergo the study and an immediate new date was set for the PET study. The acquisition was made 60 minutes after the intravenous injection of approximately 370 MBq of 18F-FDG. The area of acquisition was from head to the middle thigh in a total of 7 beds (299 images). All the studies presented correction of attenuation. Intraobserver contrast was not used in the CT.

The semiquantitative and qualitative analyses of the baseline and follow up PET/CT studies were performed by specialists in Nuclear Medicine (J.N., A.S., J.B.). Qualitative analysis consisted of the description of the hypermetabolic or hypometabolic uptake of the lesion studied as well as the remaining pulmonary and extrapulmonary lesions. The semiquantitative analysis consisted of the measurement of the SUV maximum (SUVmax) of the acquisitions in both the initial and delayed phases (Dual-Time Point technique) of the lesion studied as well as the remaining lesions.

The Dual-Time Point technique (additional acquisition in the delayed phase 2 h post-injection) is used in baseline PET/CT studies with SUVmax within the range limit for malignant pathology and in follow up PET/CT studies to differentiate tumor from inflammatory tissue. An increase of greater than 10% in the delayed phase PET study was considered malignant.

In the baseline PET/CT studies (prior to ablation) a lesion was considered benign when the SUVmax was less than 2.5 g/ml or when the SUVmax in the delayed phase was less than or equal to 10% and was greater than the value of the initial phase, if the latter value was slightly greater than 2.5 g/ml. On the other hand, a lesion was deemed malignant when the SUVmax was greater than...
Tumoral lesion

Post-ablation follow up PET/CT

A
without metabolic activity

Lesser than or equal to or greater than metabolic activity¹

Greater metabolic activity²

Reduction >25 %

Reduction equal to or greater than <25 %

SUVmax <2.5 g/ml

SUV max ≥2.5 g/ml

Fig. 1. Scheme of the different metabolic findings observed in the follow up PET/CT study after ablative therapy of the tumor lesion. 1: increase <10% of the metabolic activity compared to PET/CT prior to ablation; 2: increase >10% of the metabolic activity compared to PET/CT prior to ablation. Different post-ablation PET/CT findings: complete response (A); progressive disease (B); no response (C) and partial response (D and E).

or equal to 2.5 g/ml or when the SUVmax of the delayed phase was greater than 10% the value of the initial phase, if this latter value was slightly less than 2.5 g/ml.

Interpretation of the therapeutic results

The results of the ablation technique according to the follow up PET/CT study (Fig. 1) were classified as: complete response (CR) when the follow up PET/CT study was compatible with non-viable tumor tissue (NVTT) (Fig. 1A); partial response (PR) when the follow up PET/CT study was compatible with viable tumor tissue (VTT) with a SUVmax >25% lower than the baseline PET/CT value (Fig. 1D) or when the SUVmax of the follow up PET/CT was >25% lower compared to the baseline PET/CT value and with a gross value <2.5 g/ml, leading to differential diagnosis between VTT or inflammatory NVTT (Fig. 1E); no response (NR) when the follow up PET/CT study presented a SUVmax value lower than (not >25%) or greater than (not >25%) compared to the baseline PET/CT value (Fig. 1C); and progressive disease (PD) when the follow up PET/CT showed a SUVmax value >25% compared to the baseline PET/CT (Fig. 1B).

We compared the results of the baseline PET/CT and CT studies with respect to the decision to perform ablation, the follow up PET/CT and CT studies with the evolution of the lesion treated and the therapeutic approach followed according to the results of the imaging techniques (outcome control, palliative care, repeated ablation or changes in medical treatment).

Results

A total of 7 lesions were treated at the following localizations: left upper lobe (1), right lower lobe (1), left lower lobe (3), and right upper lobe (2). The sizes of the lesions in the pre-ablation CT or ¹⁸F-FDG PET/CT studies ranged from 17 to 28 mm (except for one which was of 48 mm).

The mean time between the baseline ¹⁸F-FDG PET/CT and the ablation procedure was 1.8 months, being of 3.4 months between the intervention and the follow up ¹⁸F-FDG PET/CT studies. Table 2 shows the statistical results.

All the lesions treated with ablation presented hypermetabolic activity in the baseline ¹⁸F-FDG PET/CT with a mean SUVmax activity of 7.6 g/ml. After the ablation, therapy metabolic activity with a mean SUVmax of 4.3 g/ml was observed in the follow up ¹⁸F-FDG PET/CT study (Table 2). We found that the post-ablation follow up ¹⁸F-FDG PET/CT studies performed at a mean of 3.4 months (time between ablation and follow up PET) demonstrated residual metabolic activity in 88% of the patients (PR or residual inflammatory activity or stable lesion with no response to treatment) with a mean reduction of metabolic activity of 34% in lesions later confirmed by their increase in size in the follow up CT, by changes in medical treatment or the repetition of ablation.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Time between baseline PET and ablation (in months)</th>
<th>Time between ablation and follow up PET (in months)</th>
<th>Metabolic activities in baseline PET (SUV max)</th>
<th>Metabolic activities in follow up PET (SUV max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.8</td>
<td>3.375</td>
<td>7.6</td>
<td>4.275</td>
</tr>
<tr>
<td>Typical error</td>
<td>0.34434202</td>
<td>0.58820247</td>
<td>2.17912171</td>
<td>1.52570241</td>
</tr>
<tr>
<td>Median</td>
<td>1.5</td>
<td>2.75</td>
<td>6.45</td>
<td>3.2</td>
</tr>
<tr>
<td>Mode</td>
<td>1.5</td>
<td>6</td>
<td>2.5</td>
<td>#N/A</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.97394632</td>
<td>1.66368781</td>
<td>6.16348695</td>
<td>4.31533809</td>
</tr>
<tr>
<td>Variance of the sample</td>
<td>0.94857143</td>
<td>2.76785714</td>
<td>37.9885714</td>
<td>18.6221429</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.35843373</td>
<td>-0.27597919</td>
<td>3.42012428</td>
<td>4.7291443</td>
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<tr>
<td>Coefficient of asymmetry</td>
<td>0.62718382</td>
<td>1.22153811</td>
<td>1.72791311</td>
<td>1.98440819</td>
</tr>
<tr>
<td>Range</td>
<td>2.9</td>
<td>4</td>
<td>18.6</td>
<td>14.1</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.5</td>
<td>2</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.4</td>
<td>6</td>
<td>21.1</td>
<td>14.1</td>
</tr>
<tr>
<td>Sum</td>
<td>14.4</td>
<td>27</td>
<td>60.8</td>
<td>34.2</td>
</tr>
<tr>
<td>Count</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Confidence interval (95.0%)</td>
<td>0.8142395</td>
<td>1.39087782</td>
<td>5.15280404</td>
<td>3.60771293</td>
</tr>
</tbody>
</table>
with posterior clinical stability of the activity and the target lesion or by growth observed in the control CT in the patients receiving palliative treatment.

Five of the 8 ablations (63%) presented PR or residual inflammatory lesion. The medical treatment was changed in 2 (40%), ablation was repeated in 1 (10%) and palliative care was followed in 2 (40%). Three (43%) of these PET/CT studies obtained SUVmax values less than 2.5 g/ml in which the Dual-Time Point technique was fundamental for the interpretation of the area of increased uptake as VTT (Table 3).

Fig. 2 shows the case of one patient with a pulmonary tumor lesion (positive baseline 18F-FDG PET/CT) who, following ablative treatment, showed an increase in lesion size in the CT with IVC and partial metabolic response (SUVmax 1.8) in the follow up 18F-FDG PET/CT study. The oncologic therapy was thereafter modified in this patient, with the patient currently presenting a stable lesion. Fig. 3 presents the case of a patient with positive baseline morpho-functional studies who showed PR after ablative treatment with a reduction of greater than 50% in the metabolic activity accompanied by an increase in lesion size which was interpreted as a local post-therapeutic inflammatory reaction.

Two of the 8 procedures showed NR with the medical treatment being changed in 1 (50%) and palliative treatment implemented in the other (50%).

### Table 3

<table>
<thead>
<tr>
<th>Case</th>
<th>Ablation results</th>
<th>Response to new</th>
<th>Strategy</th>
<th>Clinical situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>VTT</td>
<td>PR</td>
<td>ChT</td>
<td>Stable</td>
</tr>
<tr>
<td>Case 2</td>
<td>VTT</td>
<td>PR</td>
<td>PALLIATIVE</td>
<td>Death</td>
</tr>
<tr>
<td>Case 3</td>
<td>VTT</td>
<td>PR</td>
<td>2nd RFA</td>
<td>Stable (sr)</td>
</tr>
<tr>
<td>Case 4</td>
<td>VTT</td>
<td>PR</td>
<td>VTT (2nd RFA)</td>
<td>NR</td>
</tr>
<tr>
<td>Case 5</td>
<td>VTT</td>
<td>NR</td>
<td>PALLIATIVE</td>
<td>Progression</td>
</tr>
<tr>
<td>Case 6</td>
<td>VTT</td>
<td>CR</td>
<td>–</td>
<td>Stable</td>
</tr>
<tr>
<td>Case 7</td>
<td>VTT</td>
<td>PR</td>
<td>ChT–RDT</td>
<td>Stable</td>
</tr>
</tbody>
</table>

RFA: radiofrequency ablation; ChT: chemotherapy; RDT: radiotherapy; CR: complete response; PR: partial response; NR: no response; NVTT: non viable tumoral tissue; VTT: viable tumoral tissue.

One of the 8 procedures (12%) presented CR (NVTT) with the patient being clinically stable and the lesion morphologically unmodified in the follow up CT study with IVC performed 1 year after treatment (Table 3).

With a yield of 100%, the baseline PET/CT studies identified the malignant pulmonary nodules susceptible for treatment with RFA or MWA, achieving confirmation of the positive results (50%) and...
Fig. 3. 18F-FDG PET/CT studies and CT with/without IVC at baseline, intraoperatory and at follow up. Axial slices of baseline CT with IVC (A), baseline 18F-FDG PET/CT (B), follow up 18F-FDG PET/CT (C), follow up CT with IVC (D) and intraoperative CT without IVC with ablation needle in the tumor lesion (E) are shown. The patient presents a hypermetabolic pulmonary lesion which, in follow up 18F-FDG PET/CT images after MWA, shows a 54% reduction in metabolic activity (SUVmax 8.2 and 4.4, respectively) with no anatomical correlation showing an increase in lesion size in the CT image with IVC related to a post-treatment inflammatory reaction leading to a modification in the oncologic therapy.

modifying the negative results (25%) of the CT studies with IVC carried out prior to ablation (Table 4).

In the first 6 months after treatment during which 100% of the target lesions with viable residual tumor tissue were observed with PET/CT, the results of the CT studies with IVC performed during this same period presented different results: 3 (38%) false negative, 1 (12.5%) true negative, 2 (25%) true positive and 2 (25%) without CT study (Table 4).

Discussion

Since the end of the 1990s 18F-FDG PET has been implemented as a diagnostic technique in the field of oncology, with one of its indications being initial staging of NSCLC in patients undergoing an intention to cure intervention. At present the interest in metabolic studies with 18F-FDG PET/CT is clearly established in the evaluation of the effectiveness of the ablation of hepatic and pulmonary lesions.

Our study has demonstrated that 18F-FDG PET is a useful tool for the evaluation of response to treatment with RFA or MWA, as a predictor of local recurrence and is key in new therapeutic decision making. We have also demonstrated the utility of PET imaging to confirm or modify a result of a diagnostic baseline and follow up CT study with IVC.

Combined 18F-FDG PET/CT images provide greater diagnostic efficacy compared to CT in the initial and post-ablation evaluations.

<table>
<thead>
<tr>
<th>Cases</th>
<th>Baseline CT study</th>
<th>Baseline PET/CT study</th>
<th>Follow up CT study</th>
<th>Follow up PET/CT study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Positive</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 2</td>
<td>Positive</td>
<td>Positive</td>
<td>–</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 3 – RFA 1</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 3 – RFA 2</td>
<td>–</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 4</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 5</td>
<td>Positive</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Case 6</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Case 7</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
<td>Positive</td>
</tr>
</tbody>
</table>
of malignant pulmonary lesions. The addition of metabolic information may increase the precision of the detection of recurrence and allow earlier diagnosis to be obtained. Moreover, incidental lesions may be detected, thereby altering the therapeutic approach.\(^8\) \(^9\) \(^{18}\) F-FDG PET findings suggestive of local recurrence may precede similar CT findings, with patients having up to 6 months of difference between PET and CT in our study. This interval of time is clinically fundamental since small lesions are more inclined to require new treatment with ablation.

We also included cases with unpecific alterations identified in the CT studies with IVc in whom \(^{18}\) F-FDG PET studies later determined the malignant nature of the lesion with posterior histological confirmation. Part of the failure of the utility of these CT studies with IVc is related to the criteria of response used such as the Response Evaluation Criteria in Solid Tumors (RECIST),\(^{10}\) which is widely used in Departments of Radiodiagnosis. These failed due to dependence on the size of the lesion in this particular situation in which a mass adequately treated by ablation is always greater than the target lesion consisting of tumor tissue plus surrounding pulmonary parenchyma with inflammation due to exposure to ablation.

Metabolic lesions may optimize the evaluation of the lesions treated with ablation and substitute the parameters such as changes in size and the enhancement with IVc of the studies with morphological images. Indeed, \(^{18}\) F-FDG PET/CT may be of crucial importance in the period posterior to ablation because, in comparison with surgical resection, no histological material is available for assessment by the Department of Pathology. Early detection of post-ablation recurrence is critical since it provides the opportunity to repeat the ablation as a rescue therapy for recurrence.

The optimum time to perform a follow up \(^{18}\) F-FDG PET/CT image after ablation has yet to be established. Many studies have suggested that a control PET during the first months may be beneficial prior to ablation in both the lung and the liver and is able to precede the diagnosis by CT with IVc and even has a greater sensitivity of detection. However, \(^{18}\) F–FDG PET/CT studies carried out 6 months after ablation of NSCLC present a greater correlation with the clinical status of the patients at one year.\(^{4,11–13}\) Our study showed good results within the range of 2–6 months after treatment with ablation, with a mean of 3 months. Several studies in the literature support our results. In a study with 34 patients undergoing PET/CT FDG at 24 h, and 1 and 3 months, Deandreis et al.\(^{14}\) concluded that the 3 months following ablation is a good interval of time to limit possible false positive results due to inflammatory uptake. In a study including 15 patients undergoing baseline and follow up \(^{18}\) F-FDG PET/CT, Higaki et al. separated the intervals into 3 trimesters and concluded that the appropriate time to initiate follow up PET/CT is at least the third month post-ablation.\(^{15}\)

Despite the approximate values obtained in our study, Table 2 also shows alterations in the measures of a central trend, in those of distribution and dispersion of the times between studies and ablative therapy as well as in the baseline metabolic activities and follow up. This is due to the low number of cases included in the sample. Thus, our results should be contrasted with those obtained in future studies with a larger sample size.

To distinguish between benign and malignant metabolic uptake by metabolic imaging studies \(^{18}\) F-FDG PET cannot consider the SUV\(_{\text{max}}\) as the only variable of confidence. Factors such as the inflammatory reaction produced by the ablation technique produce increased uptake of FDG and its activity varies among the patients treated, being one of the main factors diminishing the specificity of \(^{18}\) F-FDG PET/CT studies. Several techniques among the metabolic imaging studies with PET are aimed at increasing the diagnostic yield such as the Dual-Time Point which is used by many centers of Nuclear Medicine reporting positive results with this technique,\(^{16–22}\) and was of use to identify the hypermetabolic area with an initial SUV\(_{\text{max}}\) less than 2.5 g/ml compatible with VTT in 3 cases.

**Limitations**

We performed this study in a low number of patients thereby reducing the power of the results. Our results must therefore be contrasted with those obtained in a larger sample size.

**Conclusion**

Follow up studies with \(^{18}\) F-FDG PET/CT have conditioned different therapeutic strategies adopted by oncologic physicians. The high yield of the \(^{18}\) F-FDG PET/CT study including the Dual-Time Point technique in undetermined cases may be used in substitution to the multiple follow up CT with IVc studies prior to and after treatment with RFA or MWA to thereby considerably reduce exposure to high doses of radiation. We propose that the first follow up \(^{18}\) F-FDG PET/CT study be performed at 3 months after RFA or MWA.

**Conflict of interests**

The authors declare no conflict of interest.

**References**


