High Prognostic Value of 18F-FDG PET for Metastatic Gastroenteropancreatic Neuroendocrine Tumors: A Long-Term Evaluation

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This study aimed to evaluate the long-term prognostic usefulness of 18F-FDG PET for patients with metastatic gastroenteropancreatic neuroendocrine tumors (GEPNETs). Methods: Thirty-eight patients with metastatic GEPNETs were prospectively enrolled. Initial check-up comprised CT scan, 111In-pentetreotide scintigraphy (SRS), and 18F-FDG PET. Only 18F-FDG PET–positive lesions with a maximum standardized uptake value (SUVmax) greater than 4.5 or an SUV ratio (SUVmax tumor to SUVmax nontumoral liver tissue, or T/NT ratio) of 2.5 or greater were considered positive for prognosis—that is, indicating a poor prognosis. Progression-free survival (PFS) and overall survival (OS) were estimated using the Cox regression model. Results: Median PFS and OS were significantly higher for patients with a negative 18F-FDG PET finding, with an OS of 119.5 mo (95% confidence interval [CI], 72–∞) than for patients with a positive 18F-FDG PET finding (only 15 mo [95% CI, 4–27]) (P < 10−9). Median PFS and OS were significantly higher for the patient group that had a positive SRS than the group with a negative SRS (P = 0.0002). For patients with a positive SRS, PFS and OS were significantly shorter when the 18F-FDG PET finding was positive: 19.5 mo (95% CI, 4–37) for PFS and 119.5 mo (95% CI, 81–∞) for OS (P < 10−9). In the patient group with a low-grade GEPNET and a positive SRS, PFS and OS were also significantly lower for patients with a positive 18F-FDG PET. At 48-mo follow-up, 100% of patients who had a positive 18F-FDG PET for disease progression (of which 47% were also SRS-positive) were deceased, and 87% of patients with a negative 18F-FDG PET were alive (P < 0.0001). The T/NT ratio was the only parameter associated with OS on multivariate analysis. Conclusion: Overall, 18F-FDG PET appears to be of major importance in the prognostic evaluation of metastatic GEPNET. A positive 18F-FDG PET with an SUV ratio (T/NT) of 2.5 or greater was a poor prognostic factor, with a 4-y survival rate of 0%. A positive SRS does not eliminate the need for performing 18F-FDG PET, which is of greater prognostic utility.

Key Words: prognosis; PET; FDG; neuroendocrine

Gastroenteropancreatic neuroendocrine tumors (GEPNETs) are rare and form a heterogeneous group of tumors, with different progression profiles (1).

Different histoprognostic classifications (2–4) have been proposed, but determining the prognosis for neuroendocrine tumors (NETs) remains problematic even in the case of metastatic disease. These tumors are characterized by somatostatin receptor expression, which varies quantitatively and qualitatively from one tumor type to another (5).

It is now clearly known that functional imaging based on somatostatin receptor expression (111In- or 68Ga-radiolabeled analogs) has better diagnostic performance than 18F-FDG PET. It is also known that somatostatin receptor expression correlates with well-differentiated NET (6–8) and is a favorable prognostic factor (9–11).

In contrast, a positive 18F-FDG PET finding would correlate with a poorly differentiated NET and be a poor prognostic factor. But so far, only few studies have been performed on this subject (9,11,12). The main objective of our study, with preliminary findings already published (9), was to evaluate on a long-term basis the progression-free survival (PFS) and overall survival (OS) of metastatic GEPNET patients based on 18F-FDG PET and 111In-pentetreotide scintigraphy (SRS) results.

MATERIALS AND METHODS

In this prospective study, 38 patients with a histologically confirmed metastatic NET, mainly gastroenteropancreatic (n = 36), were enrolled from September 2003 to January 2006. The trial was approved by the ethics committee of our university hospital, and written informed consent was obtained from each patient. There were 24 men and 14 women (mean age ± SD, 60 ± 15 y).

The primary tumor site was known for 26 patients (pancreas, 9; midgut, 11; hindgut, 3; lung, 2; and gallbladder, 1). For the other 12 patients, the primary tumor site was unknown, but they had neuroendocrine hepatic metastases.

18F-FDG PET AND NEUROENDOCRINE TUMORS • Bahri et al.
All of the patients had metastatic disease. The site of metastases was as follows: liver (n = 34 patients), lymph nodes (n = 15), peritoneum (n = 8), bone (n = 3), lungs (n = 1), central (n = 1), and ovaries (n = 1). The Ki67 index was available for 34 patients, established at less than 2% in 13 patients and greater than 15% in 7. Four tumors were classed as high-grade according to the World Health Organization (WHO) classification. Of the 34 low-grade tumors (WHO), 4 were classed grade 3 high-grade according to the European Neuroendocrine Tumor Society classification.

The statistical analyses were conducted using SPSS software (IBM). The significance level was set at 0.05.

PFS and OS were estimated using the Kaplan–Meier method, and their comparison was based on log-rank test.

Using univariate analysis, we found SUV, T/NT ratio, Ki67, and histologic grade to significantly correlate with PFS and OS (Table 3). Yet at multivariate analysis, T/NT ratios were still found to significantly (P < 0.0001; relative risk of death: 26.8) correlate with OS (Table 3).

Fifteen patients (39%) had a positive 18F-FDG PET. PFS and OS were highly significantly better in the patient group with a negative 18F-FDG PET than in the patient group that had a positive 18F-FDG PET and SRS positivity or negativity related to the histologic grade and Ki67 are presented, respectively, in Tables 1 and 2. 18F-FDG PET correlated with the histoprognostic grade (P < 0.01) and Ki67 (P < 10⁻³) whereas SRS results did not.

The identified thresholds of positivity for prognosis were 4.5 for SUV (area under the ROC curve, 0.897) and 2.5 for T/NT ratio (area under the ROC curve, 0.920), (Fig. 1).

Fig. 1: ROC curves for SUV and T/NT ratio for identification of poor prognosis (i.e., rapidly progressive disease).

TABLE 1
Results Using 111In-Octreotide Scintigraphy and 18F-FDG PET Scanning (n = 38 Patients)

<table>
<thead>
<tr>
<th>Modality</th>
<th>PET+ *</th>
<th>PET−</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>111In-octreotide scintigraphy</td>
<td>7 (27)</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>(positive)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>111In-octreotide scintigraphy</td>
<td>8 (27)</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>(negative)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>23</td>
<td>38</td>
</tr>
</tbody>
</table>

*P < 2.5.

High-grade tumor according to WHO/ENETS classification.
18F-FDG PET: respectively, 71 mo (IC 95%, 50 m–∞) versus 3 mo (IC 95%, 3–6 mo), P < 0.0001, for PFS, and 119.5 (IC 95%, 72 mo–∞) versus 15 mo (IC 95%, 4–27 mo) for OS, P < 0.0001 (Fig. 2).

We observed that 23 patients (61%) had a positive SRS. PFS and OS were significantly better in the patient group with a positive SRS than in the patient group that had a negative one: respectively, 54 mo (IC 95%, 8–110 mo) versus 3 mo (IC 95%, 1.5–6 mo) for PFS, P = 0.0002, and 96 mo (IC 95%, 47 mo–∞) versus 27 mo (IC 95%, 3–41 mo) for OS, P = 0.0002 (Fig. 3).

Twenty-nine percent of the patients with a positive SRS also had a positive 18F-FDG PET (i.e., 11 patients). For those patients, PFS and OS were highly significantly better in the patient group with a negative 18F-FDG PET than in the patient group that had a positive 18F-FDG PET: respectively, 71 mo (IC 95%, 50 mo–∞) versus 6 mo (IC 95%, 3–15 mo) for PFS, P < 0.0001, and 119.5 mo (IC 95%, 81 mo–∞) versus 19 mo (IC 95%, 4–37 mo) for OS, P < 0.0001 (Fig. 4).

In the patient group with the best assumed prognostic profile—that is, patients with low-grade GEPNET (WHO/ENETS) and positive SRS—PFS and OS were highly significantly better in patients who had a negative 18F-FDG PET (of the patients of this group) than in patients who had a positive 18F-FDG PET (of the patients of this group): respectively, 71 mo (IC 95%, 50 mo–∞) versus 6 mo (IC 95%, 3–6 mo) for PFS, P < 0.0001, and 119.5 mo (IC 95%, 81 mo–∞) versus 19 mo (IC 95%, 4–37 mo) for OS, P < 0.0001 (Fig. 5).

Survival rates regarding 18F-FDG–negative and –positive patients were, respectively, 73% versus 95% (P < 0.0001) at 1 y, 40% versus 95% (P < 0.0001) at 2 y, 20% versus 91% (P < 0.0001) at 3 y, and 0% versus 87% (P < 0.0001) at 4 y.

Survival rates regarding SRS-negative and -positive patients were, respectively, 92% versus 72% (P = 0.0002) at 1 y, 81% versus 54% (P = 0.0002) at 2 y, 77% versus 27% (P = 0.0002) at 3 y, 70% versus 9% (P = 0.0002) at 4 y, and 57% versus 0% (P = 0.0002) at 6 y.

**DISCUSSION**

In this study, median PFS and OS were highly significantly better (P < 10–3) in the patient group with a negative 18F-FDG PET than in the group with a positive 18F-FDG PET (respectively,
119.5 and only 15 mo), whatever the results of other prognostic tools, including SRS and even Ki67 or histologic classification. To our knowledge, no other prospective study has performed a long-term prognostic evaluation in metastatic GEPNET patients, based on both 18F-FDG PET and SRS.

Indeed, Binderup et al. (12) evaluated survival in NET patients over only a short period (average follow-up, 11.5 mo). Median OS was not reached but the authors also found that a positive 18F-FDG PET with an SUV max cutoff of 9 strongly correlated with a greater risk of mortality (hazard ratio, 0.8; 95% CI, 2.7–28.7; \( P < 0.001 \)). In this study, a comparison with the SRS prognostic value was not performed.

A positive SRS has been reported to be factor of good prognosis (9,11,12). In our study, median PFS and OS were significantly better in the patient group that had a positive SRS than in the one exhibiting a negative SRS \( ( P < 10^{-3}) \), confirming the prognostic value of SRS. However, the prognostic value of SRS has been shown to be lower than that of 18F-FDG PET. We have, in fact, found that SRS was no longer correlated to OS when using multivariate analysis, as opposed to 18F-FDG PET.

For patients with both a positive SRS and a positive 18F-FDG PET, prognosis can be difficult to anticipate (because of the contradictory prognosis information provided by SRS and 18F-FDG PET). In this situation representing 18.2% of the global population and 25% of the positive SRS patients, our study clearly demonstrates for the first time that prognosis is related to the positivity of the 18F-FDG PET (poor prognosis), because median OS is only 17 mo when 18F-FDG PET is positive versus 119.5 mo when it is negative \( ( P < 10^{-3}) \).

Because SRS sensitivity for tumor detection is far better than 18F-FDG PET (6–8), most recommendations reserve 18F-FDG PET for cases in which SRS is negative, for high-grade tumors with a high proliferation index (Ki67), or for tumors shown to be rapidly progressing based on morphologic examinations (13–15).

However, in our results 25% of the patients with a positive SRS and 21% of the patients who had a tumor with a low proliferation index (Ki67 < 2%) also had a 18F-FDG PET–positive result and a poor prognosis. Binderup et al. (12) reported similar findings, namely 40% of patients who had a NET with a low proliferation index (Ki67 < 2%) had a positive 18F-FDG PET. These results are of great interest, suggesting that 18F-FDG PET is indicated in metastatic NETs, even in cases of low Ki67 index (i.e., <2%).

Elsewhere, the usefulness of SRS in known metastatic NETs remains a matter of debate. Given its lower prognostic impact than 18F-FDG PET, it should be performed solely if surgery or radiolabeled somatostatin analog therapy is proposed, and this is still the case for patients with a high Ki67 index, because 42% of our patients with a Ki67 index of 15% or greater also exhibited a positive SRS.

In the patient group having both a low-grade NET (WHO/ENETS) and a positive SRS \( (n = 23) \), 3 patients also had an 18F-FDG PET–positive finding. Here again, median PFS and OS were highly significantly lower when 18F-FDG PET was positive versus when it was negative \( ( P < 10^{-3}) \).

FIGURE 3. PFS and OS probabilities (time in mo) related to SRS.

FIGURE 4. PFS and OS probabilities (time in mo) for SRS-positive patients related to 18F-FDG PET.
The coexistence in the same patient, or even in the same tumor, of well-differentiated and poorly or undifferentiated tumor clones (5) may explain why some NETs exhibit uptake of both 111In-pentetreotide and 18F-FDG. This coexistence would also explain the variability of tumor behavior and the sometimes fatal progression of certain patients with a NET who had wrongly been classed as of low risk.

Thus, in the case of metastatic NETs, 18F-FDG PET should be more widely used for prognostic evaluation.

The prognostic impact of 18F-FDG PET is confirmed by the long-term evaluation with an overall 4-y survival rate of 0% in the patient group that had a positive 18F-FDG PET, compared with 87% in the group that had a negative 18F-FDG PET. On the basis of this finding, 18F-FDG PET appears to be of dramatic prognostic value. This point is of major interest because aggressive therapeutic approaches including chemotherapy, radiolabeled somatostatin analog internal radiation therapy (for SRS-positive patients), liver radioembolization (especially for PET-positive and SRS-negative patients), or targeted therapy can be proposed to patients with poor prognosis.

The main drawback of this study is a relatively small number of patients and heterogeneity of the population (NETs of different origin), but these drawbacks are almost always the case in others’ published data on PET and NETs. The interesting result observed in this prospective study—the highly significant dramatic prognostic impact of 18F-FDG PET in metastatic patients—should be validated in a larger multicentric trial. The prognostic value of 18F-FDG PET has also to be evaluated in nonmetastatic patients.

CONCLUSION

Our study results clearly demonstrate the usefulness of 18F-FDG PET for metastatic GEP NET. A positive SRS does not eliminate the need for an 18F-FDG PET, because 18F-FDG PET is of greater prognostic value even when SRS is positive or in some cases of low-grade lesions.

Early prognostic assessment of these tumors could be used for the selection of patients requiring aggressive treatment. The prognostic value of 18F-FDG PET in nonmetastatic patients has also to be evaluated because it was not evaluated in this study.

DISCLOSURE

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REFERENCES


FIGURE 5. PFS and OS probabilities (time in mo) for the group of patients with both SRS positivity and low grade.