Evaluation of FDG Uptake by Renal Malignancies (Primary Tumor or Metastases) Using a Coincidence Detection γ Camera

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The aim of this study was to evaluate the usefulness of FDG scanning using an ordinary γ camera equipped with coincidence detection (CDET) for 2 renal cancer indications: characterization and staging of renal masses before nephrectomy and search for recurrence after nephrectomy. **Methods:** Between September 1997 and June 1998, a whole-body scan and at least 1 tomoscintigram were obtained on 23 occasions in 22 patients (fasting for at least 6 h) using a Prism XP 2000 CDET γ camera; scanning was begun 45 min after intravenous injection of 150–250 MBq FDG. **Results:** Postoperative histologic evidence was obtained from 13 of 16 patients who underwent FDG using a CDET γ camera before renal surgery; 4 renal masses did not accumulate FDG (3 true-negatives, 1 false-negative), whereas 9 renal tumors accumulated FDG (8 true-positives, 1 false-positive). In the other 3 patients, only 1 extrarenal site of FDG uptake was checked and confirmed on histologic examination: a bone metastasis from renal cell carcinoma in 2 cases and lymph node metastasis from a squamous cell carcinoma (3 true-positives). The primary local and regional staging of the malignant renal tumors was accurate in the 9 patients who underwent nephrectomy (8 true-negatives, 1 true-positive). The primary distant staging was positive in 1 case (focus in the chest corresponding to a probable true-positive on follow-up). In the 7 examinations performed because of suspected recurrence of renal cell carcinoma several months after nephrectomy, metastases were visualized by FDG in 4 patients, confirmed by biopsy in 2 patients, and confirmed by conventional imaging or follow-up (or both) in 2 patients. The other 3 patients had negative FDG scans, corresponding to probable true-negative results on follow-up. **Conclusion:** FDG using a CDET γ camera can be used effectively for the staging and restaging of renal tumors and might be useful for characterization of the primary renal tumor in doubtful cases.

Key Words: renal cancer; FDG; coincidence detection γ camera

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For several years, FDG has been recognized as a prominent imaging agent in oncologic examinations using PET scanners (*1*). Malignant tumors usually take up glucose and FDG avidly because of increased membrane glucose transport and increased glycolytic enzyme activities in tumor cells. FDG is phosphorylated by hexokinase and then metabolically trapped in the cell (*2*).

However, PET scanners are expensive and are not widely available. Dual-head γ cameras are in more widespread use and are accessible. Therefore, efforts have been made to perform FDG imaging using ordinary γ cameras.

Attempts to adapt ultra-high-energy collimators to dual-head γ cameras to obtain FDG images (considering ^{18}F as a single-photon x-ray emitter of 511 keV) have led to slightly lower clinical performance than those of PET (*3–5*). More recently, ordinary dual-head γ cameras have been equipped with coincidence detection (CDET) and thick crystals to detect FDG by means of the coincidence emission of the two 511-keV photons in the same way as PET scanners (*3*).

We acquired this type of CDET γ camera at the end of June 1997. This study was designed to assess the clinical performance of FDG scintigraphy in renal cancer, a disease explored infrequently by FDG with PET systems and, to our knowledge, not yet addressed with CDET γ cameras. We chose to evaluate 2 renal tumor indications: characterization and primary staging of renal tumors before surgical resection and restaging for recurrence after nephrectomy.

MATERIALS AND METHODS

γ Camera and FDG Imaging Methods

Since July 1997, we have used a Prism 2000 dual-head γ camera (Picker International, Inc., Cleveland Heights, OH) equipped with CDET and a sodium iodine crystal 19-mm thick (instead of 9.5-mm thickness in ordinary γ cameras). To detect ^{18}F, the collimators were removed and replaced by axial filters that limit acceptance of annihilation photons in the axial direction to 12°. Switching to the CDET mode is completely automatic. An energy spectrum is displayed. We chose to accept only those photons with an energy of 511 keV ± 20%. Each tomoscintigraphic acquisition, involving an effective field of view of 35 cm, was performed using 30 steps of 6° lasting 60 s at the start of acquisition (and then longer as ^{18}F decays). The total duration of tomoscintigraphic acquisition was 40 min. The transaxial tomoscintigraphic spatial resolution is 5.8 mm (NU-2 1994 protocol; National Electrical Manufacturers Association, Rosslyn, VA), and the tomoscintigraphic sensitivity expressed

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as a true counting rate is 1.35 kcts/kBq/mL. No scatter correction was applied. Slices were reconstructed by means of an iterative algorithm (Ordered Subset Maximum Likelihood Expectation) that minimizes artifacts in the vicinity of physiologically hyperactive organs such as the urinary bladder. Since the middle of September 1997, whole-body imaging, performed by limited-angle tomography, has also become available, with an acquisition time of 30 min.

FDG was purchased from Hôpital Erasme (Université Libre de Bruxelles, Brussels, Belgium), refiltered, and rechecked before injection into the patient.

Imaging Protocol

Patients were told to remain fasting for at least 6 h before the examination to minimize the competitive effect of a high arterial glucose level and to lower myocardial glucose uptake. The intravenous injection of 150–250 MBq FDG was performed through an infusion line connected to saline. After injection, the patient remained lying down with minimal muscular activity for 45–60 min. The patient was then instructed to void and was subsequently positioned between the 2 heads of the γ camera for imaging; the patient's arms were at the sides for whole-body imaging and above the head for tomoscintigraphy. A whole-body scan and an abdominal tomoscintigraph were systematically acquired. When necessary, according to the patient's history and the results of the whole-body scan, a second tomoscintigraph was also acquired.

To calculate the contrast values of pathologic areas, regions of interest (ROIs) were drawn over pathologic foci, and their corresponding counts were divided by those in identical ROIs placed either on contralateral renal parenchyma in the case of primary renal tumor or on the contralateral site in the case of metastases. All ROIs were drawn on 1 slice chosen from the coronal slices obtained by tomoscintigraphy, except in 1 case in which the ROIs were drawn on a pseudocoronal slice obtained from whole-body scanning.

In the renal area, the ROI was drawn on the parenchyma, taking care to avoid the urinary collecting system. In renal tumors with an active appearance in the periphery and a photopenic appearance in the center, the ROI included only the periphery of the tumor (i.e., most active area). The mean size of the ROIs drawn on the kidneys in patients was 41 $\pm$ 20 pixels. To evaluate the value of contrast in subjects without evidence of renal pathology, we measured the renal contrast ratio in 22 control patients (without significant difference of mean age and sex ratio compared with the patients with renal tumor) who were referred for various nonrenal abdominal oncologic diseases. The mean ratio was obtained by dividing the counts within an ROI drawn on the parenchyma of the right kidney by the counts within an ROI of the same area drawn on the left kidney. The mean ratio was 0.99 $\pm$ 0.09; the mean size of the ROIs was 40 $\pm$ 12 pixels in these control patients. From these data, the reference interval for the contrast ratio was determined using the 95% confidence interval mean $\pm$ t (20 degrees of freedom) $\times$ SD. The upper limit was calculated to be 1.18.

Patients

Twenty-two patients (16 men, 6 women; age range, 42–77 y; mean age, 54 y) presented on 23 occasions between September 1997 and June 1998. Because FDG was not registered in France at that time, an individual authorization for use was obtained for each patient from the Agence du Médicament before injection, and each patient's informed consent was obtained. No patients with a history of diabetes or severe intercurrent illness were included in the study. Sixteen examinations were performed on patients with a renal mass for both characterization of the tumor and primary staging. Seven examinations were performed for suspicion of recurrence after nephrectomy: FDG scans were designed to characterize abnormal images visualized on conventional images in 4 cases, characterize a swelling of the arm in 1 case, and check for complete removal of a large renal tumor in 2 cases. Two successive examinations were performed in 1 patient (patient 12) before and after nephrectomy.

RESULTS

Characterization of Renal Mass and Primary Staging

Characterization of Renal Mass. Sixteen patients with a renal mass were evaluated, and nephrectomy or surgical resection of the mass was subsequently performed in 13 of them. Four tumors were benign, ranging in diameter from 2.5 to 9.5 cm. Nine tumors were malignant, corresponding to 7 renal cell carcinomas (diameter range, 2.8–9 cm) and 2 carcinosarcomas (diameter, 14 and 17 cm). Three of the 4 benign tumors were successfully characterized by FDG, without contrast to healthy tissue (a value of 1.0, which is true-negative for benign tumors), and 1 corresponded to a false-positive result with a contrast ratio of 1.3 in a patient with renal tuberculosis (patient 11). In the 7 cases of renal cell carcinoma, the contrast ratio ranged from 1.2 to 1.8 in 6 cases (6 true-positive results), but 1 case presented no contrast (a value of 1.0 in patient 6 corresponding to a false-negative result for a malignant tumor). Finally, in the 2 cases of carcinosarcomas, the contrast was higher than in renal cell carcinoma, with contrast ratios of 4.4 and 3.0, respectively, between the most active uptake area in the periphery of the huge mass and that in the normal contralateral kidney. Thus, using postoperative histology as the reference standard, sensitivity was 88% (8/9), specificity was 75% (3/4), and accuracy was 85% (11/13). The results of FDG scintigraphy in these 13 patients who underwent renal surgery are summarized in Table 1.

On the other hand, characterization of the renal mass, as visualized by CT or MRI (or both), was correct in 11 cases (2 true-negatives and 9 true-positives) and incorrect in 2 cases (2 false-positive results corresponding to a cyst in patient 2 [true-negative for FDG uptake] and renal tuberculosis in patient 11 [false-positive for FDG uptake]); sensitivity = 100% (9/9) and specificity = 50% (2/4). Figure 1 depicts a case of primary renal cell carcinoma with moderate FDG uptake, which was easily distinguished from physiologic activity in the normal kidney on visual inspection, especially on the coronal tomographic view, but with a contrast ratio of only 1.2 (considered as the lower threshold).

Primary Staging. Primary local and regional staging of malignant renal tumors was correct in the 9 patients who underwent nephrectomy (8 true-negatives and 1 true-positive [patient 12] corresponding to adjacent invasion of a vertebra with a contrast ratio of 4.1). No histologic evidence of lymph node metastases or renal vein involvement was found in these 9 patients. CT scanning adequately described the contiguous bone invasion in patient 12 but, in another

TABLE 1
FDG Results for Characterization of Renal Tumors in 13 Patients Treated Surgically*

Patient no.	Sex	Age (y)	Tumor size† (cm)	Histology	Fuhrman histologic grade of RCC	Contrast ratio‡	FDG result
1	M	58	2	Renal cyst	—	1.0	TN
2	M	54	2	Renal cyst	—	1.0	TN
3	F	48	2.5	Angiomyolipoma	—	1.0	TN
4	M	48	2.8	RCC	II	1.5	TP
5	F	54	3	RCC	II	1.4	TP
6	M	52	3	RCC	III	1.0	FN
7	M	50	4.5	RCC	II	1.2	TP
8	M	64	5	RCC	II	1.8	TP
9	M	42	6	RCC	II	1.5	TP
10	F	57	9	RCC	II	1.2	TP
11	F	45	9.5	Renal tuberculosis	—	1.3	FP
12	M	49	14	Carcinosarcoma	—	4.4	TP
13	F	53	19	Carcinosarcoma	—	3.0	TP

*Classification by ascending tumor size.
†Maximum diameter.
‡Renal tumor-to-normal kidney ratio.
RCC = well-differentiated renal cell carcinoma; TN = true-negative; TP = true-positive; FN = false-negative; FP = false-positive.

patient, suggested probable involvement of the adjacent calix that was not confirmed at surgery (false-positive of CT scan, true-negative for FDG uptake).

Primary distant staging was assessed on whole-body FDG images. One focus of pathologic FDG uptake was seen in the right lung of patient 13 (chest CT scan was negative at this time; FDG contrast ratio was 1.3 on the whole-body image, not to be compared with the other values of contrast that were measured on coronal tomoscintigraphic slices). This lung focus was considered to be a probable true-positive as secondary lung invasion was confirmed several months later (disseminated pulmonary metastases). Figure 2 illustrates the case of this patient with a primary huge renal carcinosarcoma and a focus of FDG uptake in the chest.

Nephrectomy was not performed in 3 of the 16 patients, each with a renal mass, because disease was known to be metastatic at the time of scintigraphic examination. Primary staging of these 3 patients by FDG was concordant with the histologic data or the data of conventional imaging, but 1 primary renal cancer did not show any significant FDG uptake (patient 15). CT data were suggestive of renal malignancy in all 3 patients, and metastatic spread was assessed by biopsy of a suspected site (lymph node in 1 patient and bone metastasis in the other 2 patients). Table 2

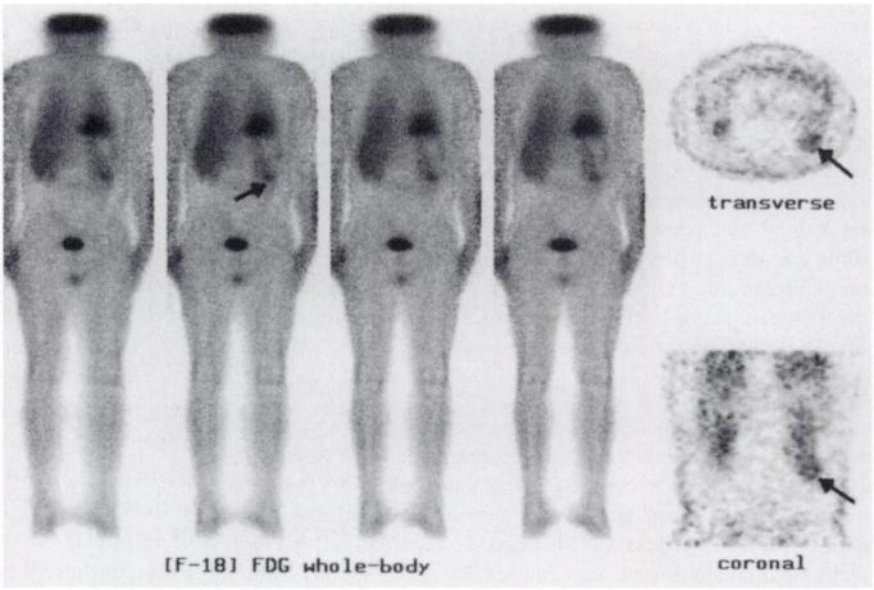

FIGURE 1. A 50-y-old man with 4.5-cm tumor of inferior part of left kidney. FDG uptake of this primary tumor, corresponding to renal cell carcinoma, is moderate (arrow) but can be visually distinguished from physiologic activity of normal kidney (contrast ratio = 1.2). Moderate uptake is better seen on coronal view than on transverse view.

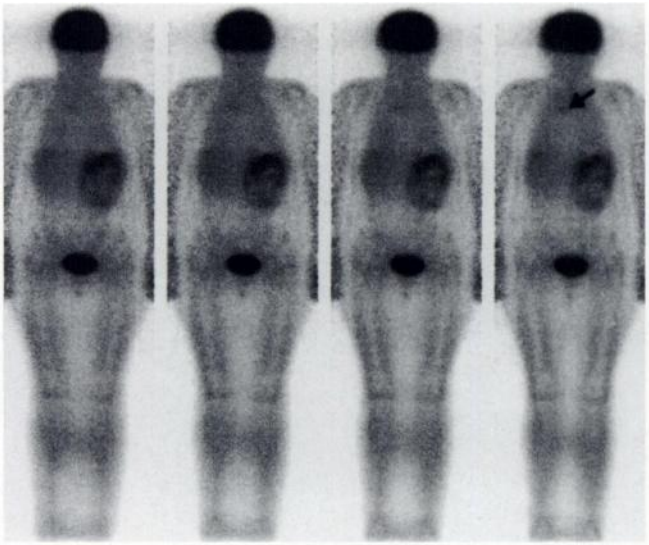

FIGURE 2. A 53-y-old woman with huge tumor of left kidney and no known secondary sites before scintigraphy. FDG uptake of periphery of tumor is high (contrast ratio between most active part of tumor and contralateral healthy kidney = 3.0). One pathologic focus of uptake in chest (arrow) corresponds to probable true-positive result on follow-up.

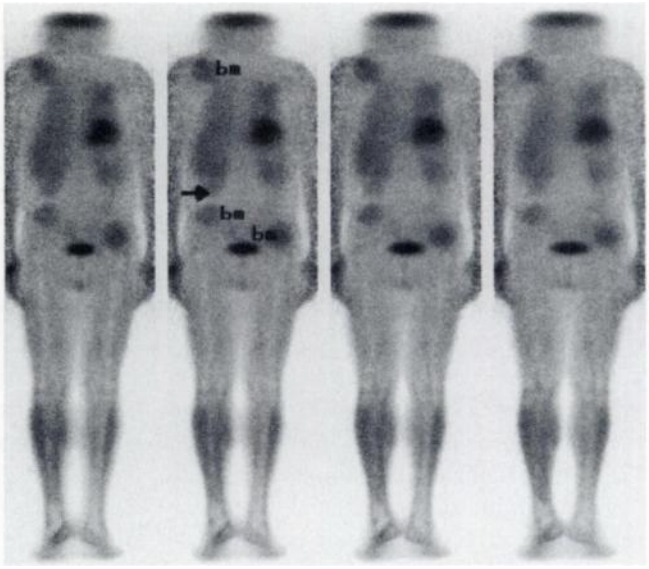

FIGURE 3. A 48-y-old man with bone metastases (bm) taking up FDG (right scapula, right ilium, and left hip) associated with primary renal cell carcinoma (arrow), with faint FDG uptake on whole-body images.

summarizes the results of FDG scintigraphy for primary staging in the 12 patients with renal cancer. Figure 3 illustrates the case of a patient with a primary renal tumor and bone metastases, both of which took up FDG.

Search for Recurrence After Nephrectomy

Seven examinations were performed after nephrectomy in patients with suspected recurrence. Metastases were visualized in 4 patients with intense FDG uptake (contrast ratios ranging between 3.2 and 20); metastases were confirmed by biopsy or surgery in 2 patients and by conventional imaging or follow-up data in the 2 other patients.

At the time of FDG scanning, performed 7 mo after nephrectomy for cancer, patient 20 suffered from a swelling of the right arm and had a palpable lymph node in the right axilla. FDG showed multiple foci of uptake in the right

TABLE 2
FDG Results for Primary Staging in 12 Patients with Renal Cancer*

Patient no.	Sex	Age (y)	FDG result for renal tumor characterization	Histology	Extrarenal site of FDG uptake	Contrast ratio†	FDG result for primary staging
4	M	48	TP	RCC	—	—	TN
5	F	54	TP	RCC	—	—	TN
6	M	52	FN	RCC	—	—	TN
7	M	50	TP	RCC	—	—	TN
8	M	64	TP	RCC	—	—	TN
9	M	42	TP	RCC	—	—	TN
10	F	57	TP	RCC	—	—	TN
12	M	49	TP	Carcinosarcoma	Single (vertebra)	4.1	TP
13	F	53	TP	Carcinosarcoma	Single (lung)	1.3‡	Probable TP
14	M	48	Probable TP (contrast ratio = 1.5)	RCC§	Multiple (bone)	2.7	TP
15	M	65	Probable FN (contrast ratio = 1.0)	RCC§	Single (vertebra)	3.0	TP
16	M	65	Probable TP (contrast ratio = 1.6)	Epidermoid carcinoma§	Multiple (lymph nodes)	3.8	TP

*Nephrectomy performed in all but 3 patients.
†Focus-to-contralateral site ratio.
‡Contrast obtained on whole-body scan (not to be compared with other contrast values obtained on tomoscintigraphic data).
§Biopsy of secondary site.
TP = true-positive; RCC = renal cell carcinoma; TN = true-negative; FN = false-negative.
Results are noted as probable TP or probable FN for renal mass or metastases when no direct histologic evidence was obtained at these sites.

arm, in the right axilla and the chest, in abdominal lymph nodes, and in the right adrenal gland. All of these secondary deposits (except for the local foci of the arm and axilla) were subsequently visualized by conventional imaging. Therefore, the extent of disease was assessed completely by FDG in a single examination, and no sites were missed.

Patient 21 had undergone nephrectomy 2 y before FDG scanning; a recurrence was suspected because of an abnormal CT image in the previous nephrectomy site that showed the presence of abdominal lymph nodes, but all of these abnormalities were equivocal. Surgery was performed in view of the area of increased FDG uptake observed both in the previous nephrectomy site and in lymph nodes, and histologic examination confirmed the multifocal recurrence.

Figure 4 illustrates the case of patient 12, who was referred for FDG scanning on 2 occasions: before and after nephrectomy. Preoperative FDG scanning showed a large renal tumor with no radioactivity in the center corresponding to a carcinosarcoma invading the adjacent lumbar vertebra. The postoperative examination was performed 2 mo after nephrectomy to confirm complete removal of this very large tumor, which was resected with the invaded adjacent bone. CT scan findings were normal; in contrast, the FDG scan was positive both in bone and in soft tissue, and persistence of neoplastic tissue was subsequently confirmed by muscle biopsy.

The other 3 patients had negative FDG scans corresponding to probable true-negative results on follow-up. Table 3 summarizes the results obtained in these patients referred after nephrectomy.

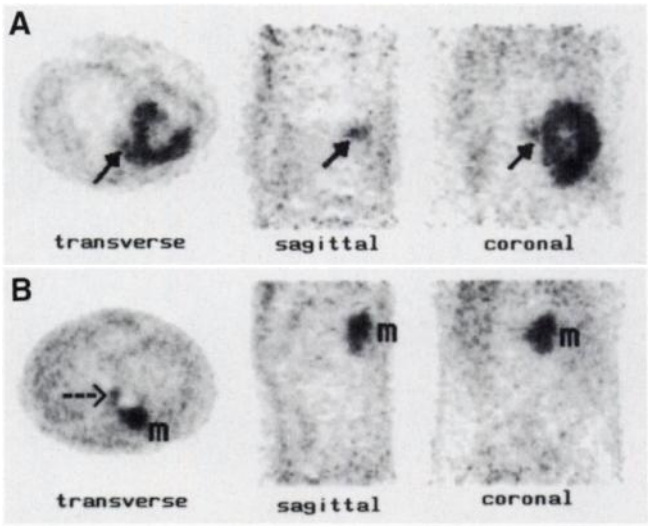

FIGURE 4. A 49-y-old man with carcinosarcoma of left kidney referred on 2 occasions: before and after nephrectomy. (A) Tomoscintigraphic slices obtained before nephrectomy show high FDG uptake corresponding to carcinosarcoma and pathologic focus (arrow) corresponding to adjacent vertebral invasion. (B) Second examination, performed 2 mo after nephrectomy to check for complete removal of large tumor, shows 2 pathologic areas of FDG uptake, whereas CT scan was normal. Pathologic areas of uptake were located in vertebra (dashed arrow) and in paravertebral muscle (m). Recurrence was confirmed by muscle biopsy.

DISCUSSION

The potential role of FDG scintigraphy in the characterization of renal tumors was reported in 1989 by Wahl et al. (*6*), who showed that FDG was avidly taken up by human renal

TABLE 3
FDG Results for Restaging After Nephrectomy

Patient no.	Sex	Age (y)	Aim of FDG scan	FDG scan	No. of foci	Contrast ratio	FDG result
12	M	49	Confirm complete removal of large renal tumor	Positive	2	3.2, 4	TP (biopsy of 1 site)
17	M	42	Confirm complete removal of large renal tumor	Negative	—	1	Probable TN (6-mo follow-up)
18	M	53	Characterize lumbar spine lesion taking up HMDP and doubtful on MRI	Negative	—	1	Probable TN (12-mo follow-up)
19	M	58	Characterize abnormal chest image on CT scan	Negative	—	1	Probable TN (6-mo follow-up)
20	F	64	Characterize swelling of right arm	Positive	Multiple (right arm, chest, abdomen)	5–14	Probable TP
21	M	51	Characterize lesion at nephrectomy site visualized on CT scan	Positive	3	16, 18, 20	TP (surgery)
22	M	77	Staging of known lymph node invasion	Positive	1 (very extensive)	8	Probable TP

TP = true-positive; TN = true-negative; HMDP = hydroxymethylene diphosphonate.
Results are noted as TP if histologic evidence was available. Results are noted as probable TP or probable TN according to clinical data or conventional imaging data (or both).

cancers in a murine xenograft model. However, we observed that, in situ, primary renal cancers, especially renal cell carcinomas, did not show marked contrast with the adjacent healthy renal tissue on FDG scanning. A more marked contrast is generally observed with other primary malignant tumors. For example, in patients referred for characterization of a pulmonary nodule imaged on the same CDET γ camera, we found a contrast threshold of 2.5 for malignancy (*7*), which is significantly higher than that for primary renal cancers with a contrast threshold of 1.2.

This mild contrast reduces the sensitivity of FDG for characterization of renal masses. In this study, the semiquantitative approach using contrast ratios did not improve the characterization obtained by visual inspection. Apart from the study by Wahl et al. (*8*), in which all 5 primary malignant renal tumors took up FDG, some false-negative results were reported in the other studies (*9,10,13*), leading to lower sensitivities for FDG than those in other primary tumors (Table 4). In this respect, the technique does not appear to offer any substantial advantage over CT and MRI, which remain as the standards of validation. FDG using CDET might therefore be useful in doubtful cases—for example, suspicion of malignant tumor on CT or MRI (or both) with negative biopsy in a patient considered to be at high risk for surgery.

However, the optimal protocol for this approach has yet to be defined. Administration of diuretics, as reported by Goldberg et al. (*9*), could be a good way to improve the mean ratio between the renal tumor and the adjacent renal tissue, but the improvement in sensitivity remains to be confirmed. This procedure presents several limitations that make the FDG examination more invasive and cause greater discomfort to the patient than other imaging procedures. Thus, the patient is likely to move during the acquisition time, which is longer with the CDET γ camera than with dedicated PET scanners. The optimal imaging time has also not been defined. Wahl et al. (*8*), using a nude mouse model, reported that the tumor-to-normal kidney ratio increased continuously with time from 0.73 ± 0.09 at 20 min after FDG injection to 2.64 ± 0.21 at 4 h after injection. To our knowledge, in all reported clinical studies, imaging started about 1 h after FDG injection. Therefore, acquisition of later images would be interesting, but decay of the tracer, leading to lower counts, makes this procedure difficult to perform in routine practice. The effects on the image of the lack of attenuation correction and the contribution of scattered and random coincidences have also to be considered in these tumors with a weak FDG uptake.

The mechanisms accounting for this mild contrast are probably linked to both the normal accumulation in kidney and some characteristics of the renal tumor itself or its accessibility to nutrient supplies. Because FDG is excreted by the kidney, the concentration of FDG is physiologically high in the urinary collecting system. The renal parenchyma shows only moderate FDG uptake, probably because renal tubular glucose receptors do not have a high affinity for FDG (*9*). Little tubular reabsorption occurs, therefore accounting for the rapid clearance of the tracer from the blood pool by urinary excretion (*9*).

Miyauchi et al. (*10*) studied 11 patients with renal cell carcinoma, including 5 with a negative FDG PET scan, to correlate the biologic characteristics of renal cell carcinoma with FDG uptake. They found that those renal cancers that were well visualized with FDG PET had a higher grade, had a higher Glut-1 expression, and tended to be larger than the poorly visible cancers. The results of this study relating to an effect of tumor grade disagree with the results of Miyauchi et al. because, in this series, the only renal cell carcinoma with no FDG uptake had a higher grade (Fuhrman III) than did the others, which were all Fuhrman grade II. The histologic type of the renal cancer also appears to play an important role because renal cell carcinomas showed lower FDG uptake than did carcinosarcomas. Another mechanism that can be proposed to explain the mild or absent contrast observed in primary renal cancers is a lack of accessibility of the tracer to tumor cells. In a study using ^{111}In-pentreotide and thallium as radiotracers in patients with renal tumors, Montravers et al. (*11*) found that, in situ and in vivo, these tumors did not take up either pentreotide or thallium and appeared photopenic on tomoscintigraphy when they ex-

TABLE 4
FDG PET Studies in Renal Cell Carcinoma

Reference	No. of patients	Characterization of primary tumor	Locoregional staging	Distant extension
Wahl et al. (*6*)	5	Sen = 5/5	Sen (site based) = 3/3 (3 sites TP), Spec (site based) = 6/6 (6 sites TN)	Sen (patient based) = 1/1, Spec (patient based) = 4/4
Bachor et al. (*13*)	29	Sen = 20/26, Spec = 0/3		
Goldberg et al. (*9*)	21	Sen = 9/11, Spec = 10/10		
Miyauchi et al. (*10*)	11	Sen = 6/11		
Hoh et al. (*14*)	10			Sen (patient based) = 10/10, Sen CI (patient based) = 7/10

Sen = sensitivity; TP = true-positive; Spec = specificity; TN = true-negative; CI = conventional imaging (CT or MRI [or both]).

ceeded 5 cm in diameter. Nevertheless, some metastases were seen with both radiopharmaceuticals, even when the primary tumor was not visible with pentreotide or thallium (or both). We therefore formulated the hypothesis of a lack of accessibility of radiotracers in vivo in these large tumors. This hypothesis was supported by an in vitro autoradiographic study (*11*) that showed the presence of pentreotide receptors in the tumor, even when the tumor was not visualized with ^{111}In-pentreotide in vivo.

In this study, we observed 1 false-positive result associated with tuberculosis and 3 true-negative results associated with other benign masses (1 angiomyolipoma and 2 renal cysts). Acute infectious or inflammatory conditions are known to induce false-positive FDG uptake (*12*). CT accurately characterized the angiomyolipoma, but the 2 cysts were considered to be suggestive of neoplastic masses. In the study of Goldberg et al. (*9*), specificity was 100%; on the contrary, the 3 benign tumors (angiomyolipoma, pericytoma, and pheochromocytoma) in the study of Bachor et al. (*13*) were false-positives (Table 4).

The potential role of FDG scintigraphy for primary local and regional staging of renal cancer could not be evaluated in the patients of this study because no lymph node or vein involvement was observed during surgery. In the studies of Bachor et al. (*13*) and Wahl et al. (*8*), FDG PET was able to detect all sites of regional lymph node metastases and renal vein involvement (Table 4) without false-positive results. In the series of Wahl et al., CT findings were in accordance with those of FDG PET, except in 1 patient falsely considered by CT to present with lymph node invasion.

In this investigation, the search for local recurrences or distant metastases, before or after nephrectomy, appeared to be a good indication for FDG CDET scintigraphy because metastases and recurrences showed high-intensity FDG uptake (mean contrast ratio = 9.5), and no sites were missed, as confirmed on follow-up at 6–12 mo. In addition, an advantage of FDG scanning in this regard is whole-body imaging in a single study with the ability to explore the limbs. In 1 patient we studied, a clear pathologic uptake in the right arm was indeed seen. The other advantages of FDG scanning are the noninvasiveness (no allergy) and the favorable dosimetry (less than that of a typical CT scan). The results obtained with a CDET γ camera did not appear to differ from the few published results on renal cancer imaging using dedicated PET systems, especially in the search for metastases (*8,14*) (Table 4).

CONCLUSION

FDG using CDET can be used effectively for the detection of metastases of renal cancer in staging or restaging and might be useful for primary local and regional staging of these tumors. The clinical usefulness of FDG scanning for characterization of the renal masses appears to be more doubtful with either the PET or CDET system. Further evidence relating to the best examination protocol is lacking. To indicate surgical intervention on a renal tumor, FDG using a CDET γ camera might therefore be useful in doubtful cases—for example, suspicion of malignant tumor on CT with negative biopsy in a patient considered to be at high risk for surgery.

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