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Purpose: The aims of this prospective study were to investigate the potential role of fluorine-18-deoxyglucose (FDG) positron emission tomography (PET) in determining the efficacy of the local tumor ablative process and to determine the added value of FDG-PET in the detection of tumor recurrence during follow-up.

Patients and Methods: Twenty-three patients with unresectable colorectal liver metastases were followed up after local ablative therapy consisting of a standard protocol including FDG-PET scanning, computed tomography (CT) scanning, and carcinoembryonic antigen measurements. The mean follow-up period was 16 months (range, 10 to 21 months).

Results: Ninety-six lesions was treated, 56 by local ablative treatment. Within 3 weeks after local ablative treatment, 51 lesions became photopenic on FDG-PET, while five lesions (in five patients) showed persistent activity on FDG-PET. In four of five FDG-PET-positive lesions, a local recurrence developed during follow-up; one FDG-PET-positive lesion turned out to be an abscess. None of the FDG-PET-negative lesions developed a local recurrence during a mean follow-up period of 16 months. During follow-up, 11 patients showed recurrence in the liver outside of the treated area. In all cases, previously negative FDG-PET scans became positive. Extrahepatic recurrence was encountered in nine patients during follow-up; FDG-PET showed all nine cases of tumor recurrence. There was one false-positive FDG-PET caused by an intra-abdominal abscess. In all patients, the time point of detection of recurrence by FDG-PET was considerably earlier than the detection by CT.

Conclusion: FDG-PET seems to have a significant impact in measuring treatment efficacy directly after local ablative therapy. Furthermore, FDG-PET has an added value in patient follow-up because it reveals recurrences earlier than conventional diagnostic modalities.
enema of the colon or coloscopy, and serum carcinoembryonic antigen (CEA) measurements. No postoperative adjuvant chemotherapy was given.

Operative Technique

Surgery was performed through an extended right subcostal incision. The abdominal cavity was thoroughly explored to exclude extrahepatic disease. Biopsy specimens and fresh frozen sections were taken in case of suspicious lymph nodes or peritoneal deposits. The liver was mobilized from its ligamentous attachments, and the extent of the disease was mapped by careful palpation and intraoperative ultrasound. The number of lesions and their relationships to the major biliary and vascular structures were determined, and final resectability was assessed. Large tumor size and locoregional invasion of perihilar structures such as the diaphragm were not considered a contraindication to operation as long as resection could be performed. During all surgical procedures, resection was considered to be the treatment of choice. When complete resection could not be achieved, the decision was made either to perform CSA or RFA alone or to combine resection of the resectable lesions with local ablative therapy of unresectable deposits.¹⁷ In general, CSA was used during the early period of the study, and RFA was used during the last 10 months of the study when this technique became available in our clinic.

Technique Hepatic Cryosurgery

After localization of the liver metastases, a cryoprobe (LCS 2000; Spembly Medical, Hampshire, United Kingdom) was introduced under ultrasound guidance into the center of the tumor. During introduction, major vascular and biliary structures were avoided. After accurate positioning of one or more cryoprobe(s), liquid nitrogen was driven through the probe at −196°C. During the freezing process, continuous ultrasound monitoring of the lesion was carried out to ensure that the ice ball, visible as a hypoechoic area around the tip of the cryoprobe, exceeded the diameter of the lesion by approximately 1 cm. Two freeze-thaw cycles per lesion were performed. Inflow occlusion (the Pringle maneuver) was sometimes used to increase the efficacy of the freezing process. In general, separate lesions were frozen sequentially rather than simultaneously. After completion of the freezing procedure, cryoprobes were removed and the probe entry site was filled with fibrin sealant (Tissucol; Baxter, Utrecht, the Netherlands).

Hepatic Radiofrequency Technique

For RFA, the Cool-tip system (Radiodics; Tyco Healthcare Group LP, Burlington, MA) was used. Under ultrasound guidance, the cooled-tip electrode was placed in the center of the tumor. For lesions smaller than 3 cm in diameter, a single cooled-tip electrode was used; for lesions larger than 3 cm, RFA was performed with a cooled-tip cluster electrode. For lesions larger than 4 cm, tumor ablation was achieved by several probe insertions. RFA is based on alternating current through the tissue, thereby creating friction on a molecular level. This results in increased intracellular temperature and localized interstitial heating. During the heating process, air bubbles arise around the tip of the electrode, which creates a hyperechoic area around the probe. In RFA, not only should the tumor be necrotized but also a 0.5- to 1.0-cm thick rim (ie, a surgical safety margin) of peritumoral liver tissue should be treated in order to destroy infiltrating tumor and reduce the risk of recurrence.¹⁸

Imaging

⁴ FDG-PET scanning. A dedicated, rotating, half-ring FDG-PET scanner (ECAT-ART; Siemens/CTI, Knoxville, TN) was used for data acquisition. Before injection of FDG, patients fasted for at least 6 hours. Intake of sugar-free liquids was permitted. Immediately before the procedure, the patients were hydrated with 500 mL of water. One hour after intravenous injection of 200 to 220 MBq of FDG (Mallinckrodt Medical, Petten, the Netherlands) and 20 mg of iohexol nonionic contrast material (Omnipaque, iodine 350 mg/mL; Nycomed, Princeton, NJ) was injected. The liver was scanned in the venous phase, 70 seconds after start of the injection. Both unenhanced and enhanced helical sequences were performed at 120 kV and 15 to 300 mAS. Contiguous reconstructed sections (pitch 1:1) were obtained with 7-mm collimation. All examination results were stored on an optical disk for further review. In addition, hard copies of the scans were obtained for both series. Each hard copy was analyzed separately by two independent reviewers (G.J., S.P.S.). Consensus was obtained in all cases. Second scans were read with knowledge of the first scans (reference scans). A sharply demarcated, hypoattenuated, nonenhanced area, which decreases in size on follow-up scans, was interpreted to mean there was no residue. An enhanced hyperemic rim around the margin of the ablated tissue was considered ablation-induced hyperemia. A faint, irregular, hypoattenuated area around the margins of the ablated tumor that increased in size on follow-up scans was interpreted as residual tumor.

Results

Patients and Treatment Characteristics

Seventeen patients were treated by CSA and six patients by RFA (Table 1). Sixteen of the 23 patients had synchronous metastases, and seven showed metachronous metastases. The number of liver lesions per patient varied from one to 10. In all patients treated by CSA,¹⁷ local tumor ablation of unresectable lesions was performed in combination with hepatic resection of resectable tumor deposits. Of the six patients who underwent RFA, two patients were treated with both RFA and hepatic resection; the other four patients were treated by RFA alone.

The number of nodules treated by CSA and RFA ranged from one to seven, with a median number of 2.1 lesions for CSA and 3.5 lesions for RFA. The size of the metastases treated by CSA ranged from 1 cm to 3.5 cm, and the median size was 1 cm. The localization of CSA and RFA was performed either under ultrasound or CT guidance. For CSA, a photopenic area was seen on FDG-PET scans. Areas of focal FDG accumulation greater than background activity were interpreted as being pathologic.

CT scanning. CT examinations of the abdomen and chest were performed with a spiral CT scanner Somatom Volume Zoom (Siemens, Erlangen, Germany). All patients received diluted ionic oral contrast 1 hour before the CT examination. The liver was scanned before and after intravenous contrast injection. By use of an Envision CT injector (Medrad, Pittsburgh, PA) at a rate of 4 mL/sec, intravenous contrast material was injected through an 18-gauge catheter placed in an antecubital vein. A total of 100 mL of iohexol nonionic contrast material (Omnipaque, iodine 350 mg/mL; Nycomed, Princeton, NJ) was injected. The liver was scanned in the venous phase, 70 seconds after start of the injection. Both unenhanced and enhanced helical sequences were performed at 120 kV and 15 to 300 mAS. Contiguous reconstructed sections (pitch 1:1) were obtained with 7-mm collimation. All examination results were stored on an optical disk for further review. In addition, hard copies of the scans were obtained for both series. Each hard copy was analyzed separately by two independent reviewers (G.J., S.P.S.). Consensus was obtained in all cases. Second scans were read with knowledge of the first scans (reference scans). A sharply demarcated, hypoattenuated, nonenhanced area, which decreases in size on follow-up scans, was interpreted to mean there was no residue. An enhanced hyperemic rim around the margin of the ablated tissue was considered ablation-induced hyperemia. A faint, irregular, hypoattenuated area around the margins of the ablated tumor that increased in size on follow-up scans was interpreted as residual tumor.

Postablative Analysis and Follow-Up

Within 3 weeks after local ablative treatment, FDG-PET, spiral abdominal CT, and serum CEA measurements were performed. To determine treatment efficacy, the postoperative and preoperative measurements were compared. The results of these immediately postoperative investigations became the reference for further follow-up investigations. After these initial investigations, standard follow-up consisted of FDG-PET, spiral abdominal CT, spiral chest CT, and serum CEA measurements at 6 weeks after treatment and every 3 months thereafter.

Data Analysis

CT and FDG-PET images were evaluated by an independent investigator blinded to the results of CEA measurements. For every region, the concordance between CT and FDG-PET findings was verified. In case of a discordance, the FDG-PET findings were compared with the true lesion status, obtained by histopathologic confirmation (n = 1) and/or clinical follow-up by repeated imaging at least 9 months after the discordant observation. All recurrences showed a clear tendency to be enhanced on CT and FDG-PET scans. Discordant findings were subsequently classified as a true-positive, false-negative, true-negative, or false-negative. The mean follow-up period in this prospective study was 16 months (range, 10 to 21 months).

RESULTS

Patients and Treatment Characteristics

Seventeen patients were treated by CSA and six patients by RFA (Table 1). Sixteen of the 23 patients had synchronous metastases, and seven showed metachronous metastases. The number of liver lesions per patient varied from one to 10. In all patients treated by CSA,¹⁷ local tumor ablation of unresectable lesions was performed in combination with hepatic resection of resectable tumor deposits. Of the six patients who underwent RFA, two patients were treated with both RFA and hepatic resection; the other four patients were treated by RFA alone.

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varied from 1 cm to 8 cm, and for RFA, from 1 cm to 6 cm. All patients completed follow-up according to the protocol; there was no postoperative mortality. However, in one patient, the first postoperative FDG-PET scan was canceled due to clear abscess formation in the liver area. The mean follow-up period for patients was 16 months (range, 10 to 21 months).

Immediately Postoperative Imaging

Patient-based posttreatment analysis. In all 23 patients, CT scans taken within 3 weeks after local ablative therapy showed hypodense treatment areas without any evidence of tumor remnants. Air in the ablated lesions was seen on the initial CT scan in most cases. An abscess was found in one patient treated with CSA. In a second patient treated with RFA, initial CT findings were not specific (enhanced rim and presence of air) while an abscess developed several weeks after treatment.

Directly after local ablative therapy (< 3 weeks), FDG-PET was performed for 22 patients. In the patient with an abscess diagnosed shortly after CSA, FDG-PET scanning was not performed. In 17 of these 22 patients, the FDG-PET results became negative after treatment (Table 2). In five patients, FDG-PET scans remained positive (Fig 1). Three of these five patients had been treated with CSA and two with RFA. In these patients, FDG-PET scans showed focally increased activity at the edge of the treated lesions. Four of these five patients developed a local recurrence at the ablated site during follow-up. In two patients with local recurrence at the ablated site, the tumors were in the proximity of major intrahepatic blood vessels. One patient treated with RFA seemed to develop an abscess in the treated area, which led to a false-positive FDG-PET scan. In patients who also underwent resection, the operation did not significantly affect FDG-PET scanning because the area of resection did not provide artifacts on FDG-PET.

Lesion-based posttreatment analysis. In the group of 23 patients, a total of 96 lesions were treated, 56 of them by local ablative therapy. After treatment, 51 lesions became negative on FDG-PET scans, while five lesions still showed activity on FDG-PET scans. In four of these FDG-PET–positive lesions, a local recurrence was detected within 6 months after treatment; one FDG-PET–positive lesion turned out to be an abscess (Table 3). Conversely, none of the FDG-PET–negative lesions developed into a local recurrence during a mean follow-up period of

Table 1. Treatment Characteristics

<table>
<thead>
<tr>
<th></th>
<th>CSA</th>
<th>RFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Male/female</td>
<td>11/6</td>
<td>4/2</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>63.7</td>
<td>62</td>
</tr>
<tr>
<td>Range</td>
<td>51-78</td>
<td>53-72</td>
</tr>
<tr>
<td>Total no. of treated lesions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Range</td>
<td>1-10</td>
<td>1-10</td>
</tr>
<tr>
<td>No. of lesions treated with local ablative therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Range</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Diameter of lesions treated with local ablative therapy, cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Range</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>With/without additional resection</td>
<td>17/0</td>
<td>2/4</td>
</tr>
</tbody>
</table>

Table 2. Patient-Based Analysis of FDG-PET Immediately After Local Tumor Ablation

<table>
<thead>
<tr>
<th></th>
<th>CSA</th>
<th>RFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients with positive FDG-PET before treatment</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>No. of patients with negative FDG-PET after treatment</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>No. of patients with positive FDG-PET after treatment</td>
<td>3</td>
<td>2†</td>
</tr>
<tr>
<td>No. of patients who developed local recurrence at ablated site during follow-up</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

*One patient did not have the early postoperative FDG-PET due to an abscess.
†One patient had an abscess.

Fig 1. FDG-PET and CT after treatment: (A) after 3 months, (B) 6 months, and (C) 9 months. After 3 months, FDG-PET showed clear FDG accumulation, revealing residual disease. Abnormalities on CT after 3 and 6 months were interpreted as posttreatment effects; while tumor recurrence was diagnosed on CT after 9 months.
Table 3. Lesion-Based Analysis of FDG-PET and Local Recurrence After Local Tumor Ablation

<table>
<thead>
<tr>
<th></th>
<th>Recurrence</th>
<th>No Recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDG-PET positive</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>FDG-PET negative</td>
<td>0</td>
<td>51</td>
</tr>
</tbody>
</table>

16 months (range, 10 to 21 months). The positive predictive value for the detection of local recurrence in lesions with a positive FDG-PET scan after treatment was 80%; the negative predictive value was 100%.

Imaging During Follow-Up

Liver. Four patients developed local recurrence at the treated site. As mentioned earlier, in all of these cases initial FDG-PET scans (within 3 weeks after local tumor ablation) showed focal and slightly irregular uptake in the rim of the treated lesion. Unequivocal diagnosis of local recurrence, however, was made when abnormal FDG accumulation typically progressed during follow-up. Therefore, definite diagnosis of local recurrence by FDG-PET was scored after 0.5, 3, 6, and 6 months. On CT scans, these recurrences became apparent several months later, at 4, 9, 9, and 12 months, respectively. The mean time point of definite detection by FDG-PET was 3.8 months, compared with 8.5 months for CT. One patient proved to have an abscess, which led to a false-positive FDG-PET scan.

Eleven patients developed recurrent disease in the liver outside the treated area during follow-up. All recurrences were detected by FDG-PET as well as by CT. The time of detection, however, varied between FDG-PET and CT. These recurrences became apparent several months later, at 6 months (n = 3), 9 months (n = 2), 12 months (n = 3), and 14 months (n = 1) after treatment. On CT scans, these recurrences became apparent several months later, at 6 months (n = 3), 9 months (n = 2), 12 months (n = 3), 18 months (n = 2), and 21 months (n = 1). The mean time point of detection by FDG-PET was 8.1 months, compared with 11.7 months for CT (Table 4).

Extrahepatic. Nine patients developed extrahepatic recurrences during follow-up. Two patients had extrahepatic recurrences at multiple sites. In six patients, extrahepatic recurrences were located in the lungs; in one patient, recurrence was located in the abdominal wall; in three patients, extrahepatic metastases were intra-abdominal; and one patient had cerebral metastases (this patient died 10 months after local ablative treatment). Extrahepatic recurrences were definitely determined by FDG-PET at 0.5 months (n = 1), 6 months (n = 3), 9 months (n = 2), 12 months (n = 2), and 15 months (n = 1). In the first patient, the preoperative FDG-PET scan was suspicious but was judged not convincing until progression of the lesion on FDG-PET at 2 weeks after surgery. In one patient, a false-positive outcome was observed because of an extrapleural abscess. On CT scans, extrahepatic tumor lesions became apparent several months later, at 3 months (n = 1), 6 months (n = 1), 9 months (n = 3), 12 months (n = 2), and 18 months (n = 1). Furthermore, in one patient pulmonary metastases were initially missed on the CT scan, while the FDG-PET scan showed obvious multiple pulmonary metastases; however, these metastases could be seen on the CT scan in retrospect. The mean time point of detection of extrahepatic recurrence by FDG-PET was 8.4 months, compared with 9.8 months for CT.

Table 4. Tumor Recurrence During Follow-Up

<table>
<thead>
<tr>
<th>Total No. of Patients With Recurrence</th>
<th>Elevated CEA†</th>
<th>Mean Time of Detection of Recurrence by CEA (months)</th>
<th>Mean Time of Detection of Recurrence by PET (months)</th>
<th>Mean Time of Detection of Recurrence by CT (months)</th>
<th>Time Difference in FDG-PET and CT Detection (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local recurrence</td>
<td>4</td>
<td>11</td>
<td>5†</td>
<td>3.8</td>
<td>4</td>
</tr>
<tr>
<td>Liver recurrence outside treated area</td>
<td>11</td>
<td>12.3</td>
<td>11</td>
<td>8.1</td>
<td>11</td>
</tr>
<tr>
<td>Extraperitoneal recurrence</td>
<td>9</td>
<td>12.6</td>
<td>10†</td>
<td>8.4</td>
<td>8§</td>
</tr>
</tbody>
</table>

*Normal CEA <5 ng/mL.
†One patient had an abscess at the ablated area in the liver.
‡One patient had an extrahepatic abscess.
§In one patient only (in retrospect), pulmonary metastases were visible on spiral chest CT scan.

DISCUSSION

This study shows the potential role of FDG-PET in measuring the efficacy of local tumor ablation as well as the added value of FDG-PET in the detection of tumor recurrence during follow-up. The efficacy of local tumor ablation is an important prognostic factor for patients undergoing these procedures. During the process of local ablation, the destruction process cannot easily be ascertained. Ultrasound monitoring is generally used for initial positioning of the RFA or cryoprobe and to ascertain whether the cryolesion seen as a hypoechoic area or the radiofrequency-treated area seen as a hyperechoic area completely engulfs the tumor. Whether indeed tumor-cell kill occurs within these areas is, however, difficult to confirm. Temperatures reached at the edge of (large) lesions may be inadequate. Furthermore, major blood vessels may serve as “heat sinks” and prevent adequate ablation of immediately adjacent tumor. In large lesions, in which multiple probe insertions are necessary, additional repositioning of the electrode may become obscured because of the hypoechoic/hyperechoic focus appearing around the distal probe...
during the application of thermal energy. Monitoring of treat-
ment efficacy in these situations again is difficult.

PET using FDG has emerged as a promising diagnostic modality
in patients with colorectal liver metastases. Unlike conventional
diagnostic modalities, such as CT scans and ultrasound, which
require anatomic alterations for detection of malignancy, FDG-PET
provides information on tumor growth based on increased glucose
uptake and metabolism of malignant cells.

In this study, 51 lesions became FDG-PET negative directly
after local ablative therapy, meaning that FDG-accumulating
liver metastases became photopenic. Five lesions remained
FDG-PET positive. In four of five FDG-PET–positive lesions, a
local recurrence was detected within a mean follow-up period of
16 months; one FDG-PET–positive lesion was an abscess.
Conversely, none of the FDG-PET–negative lesions developed a
local recurrence in the liver during follow-up. The positive
predictive value for the detection of local recurrence in lesions
with a positive FDG-PET scan after treatment was 80%; the
negative predictive value was 100%. FDG-PET was able to give
accurate information about eventual local recurrences at a
significantly earlier stage than CT. In the future, this information
initially given by FDG-PET should lead to further investigations
to collect more precise anatomic information, by CT for exam-
ple. In this way, FDG-PET determines the need for further
investigations and guides the reading of the CT scan, which
on its own is difficult to interpret in the early period after local
ablative therapy. This combined information (FDG-PET and CT
scans) offers the opportunity to re-treat tumors at an early stage.

Although the aims of our study were to investigate the potential
role of FDG-PET in determining the efficacy of the local tumor
ablative process and to determine the added value of FDG-PET
in the detection of tumor recurrence during follow-up, we have
performed a second treatment in one patient in whom a lesion
remained FDG-PET positive after treatment. At the moment,
after our assessment of the value of FDG-PET after local
ablative therapy, we now actually do administer a second
ablative treatment on any lesions that remain positive.

During further follow-up after local tumor ablation, 11 pa-
tients developed recurrent disease in the liver outside the treated
area. All recurrences were detected by FDG-PET as well as by
CT. The time of detection, however, varied between FDG-PET
and CT. The mean time point of detection by FDG-PET was 8.1
months, compared with 11.7 months with CT. In two patients, a
surgical reintervention was performed; in the other nine patients,
chemotherapy was started.

In cases of extrahepatic tumor recurrence, FDG-PET also
seemed to be a sensitive modality. In all nine patients who
developed extrahepatic recurrence, FDG-PET scans were posi-
tive; in one patient, a false-positive outcome was observed
because of an extrahepatic abscess. One extrahepatic recurrence
(pulmonary metastases) was initially missed on the CT scan but
detected by FDG-PET. In retrospect, these pulmonary meta-
tases could be seen on the CT scan. The mean time point of
detection of extrahepatic recurrence by FDG-PET was 8.4
months, compared with 9.8 months for CT. Two patients with
pulmonary metastases underwent resection during follow-up.
The other patients received chemotherapy.

Thus, in addition to the predictive value of immediate FDG-
PET in the detection of local tumor recurrence in the liver after
tumor ablation, there may also be a role for FDG-PET during
further follow-up. Recurrences of disease outside the local
ablated area are also detected earlier by FDG-PET than by CT.

In our series, four patients underwent surgical reintervention after
the detection of recurrent disease outside the local ablated area.

Since FDG is not a tumor-specific substance, an inflammatory
process also accumulates the tracer due to increased metabolic
activity of leukocytes and macrophages. This is the major
well-known source of false-positive FDG-PET results. We also
observed two false-positive FDG-PET results, once due to
abscess formation in the treated area of the liver and once due to
an extrahepatic abscess in the abdomen. These two false-positive
FDG-PET readings did not result in a treatment alteration,
because FDG-PET was not considered the decisive modality
during this study. Postponing the FDG-PET study in case of
evidence of active focal infection may prevent false-positive
FDG-PET readings. Another limitation of FDG-PET is the
limited spatial resolution, which may lead to false-negative
results when the lesions are small (< 1 cm). False-negative
results may also occur because of an increased fasting blood
sugar level or manifest diabetes mellitus. In some studies,
patients with diabetes were therefore excluded. Two of the
patients in this study had diabetes mellitus. No false-negative
results were observed in these patients during follow-up. How-
ever, blood glucose levels were always checked as we were
aware of this potential source of error.

For over a decade it has been recognized that PET can be used
to detect recurrences from colorectal cancer after FDG admin-
istration. With regard to extrahepatic recurrence, some studies
even demonstrate that FDG-PET is more sensitive than conven-
tional cross-sectional imaging methods. Delbeke et al found in
a series of 52 patients with recurrent colorectal cancer that
FDG-PET was more accurate than CT for the detection of
extrahepatic disease (92% vs 71%, respectively). Fong et al
showed unexpected extrahepatic disease detected by FDG-PET
in 10 of 40 patients. This finding was confirmed by others.

We showed in a recent prospective study that FDG-PET led to
clinically relevant extrahepatic findings different from those
found with conventional imaging in nine of 51 patients analyzed
for hepatic resection of colorectal liver metastases. In this
study, FDG-PET findings led to a change in clinical manage-
ment in 20% of patients. In the present study, we confirm
our earlier observation and show furthermore that FDG-PET
reveals extrahepatic recurrences earlier than CT.

For the detection of liver metastases, however, the value of
FDG-PET has not been fully determined. Spiral CT is currently
regarded as the best method for evaluating the anatomy and
resectability of colorectal liver metastases. The extent of liver
involvement and the relationship of the metastases to the biliary
and vascular structures generally determine resectability of liver
metastases. Therefore, given the limited anatomic information
provided at this stage by FDG-PET, FDG-PET by itself will not
become a substitute for the anatomic imaging provided by CT.
With regard to sensitivity of tumor detection, however, several
authors have reported a higher accuracy for FDG-PET compared
with spiral CT. In a series by Vitola et al, the sensitivity for
the detection of liver metastases by FDG-PET and CT was 93% and
76%, respectively. In a study by Hustinx et al, the values were
92% and 85%, respectively. However, sensitivity of FDG-PET
for colorectal liver metastases is considered to be directly related
to tumor size, as described by Fong et al. They found that in
lesions less than 1 cm the sensitivity of FDG-PET decreased considerably to 21%. Surprisingly, our current study shows an early detection of liver recurrence, so FDG-PET was able to detect recurrences even when the lesions were small. An explanation may be the relatively high contrast of FDG-accumulating tumor remnants as compared with the photopenic background of the CSA and RFA lesions, which facilitate identification of pathologic uptake.

In this study, we routinely performed two-phase CT, as is generally recommended in the follow-up of patients after RFA of colorectal liver metastases. This is in contrast to treatment of patients with suspected recurrence of hepatocellular carcinoma after local tumor ablation. For hepatocellular carcinoma, three-phase CT is recommended because recurrence is best depicted in the early arterial phase. As stated by Chopra et al., however, arterial phase images are not recommended in patients with colorectal liver metastases after radiofrequency because they do not provide any additional information.

In our series, local recurrence after local tumor ablation was observed in 17% of the patients during a follow-up period of at least 16 months. Lesion-based analysis showed a local recurrence rate of 7% after local tumor ablation. This value for local recurrence is low in comparison with a local recurrence rate of 44% described by Adam et al. Others, however, have also reported local recurrence rates on a lesion basis as low as 2.5% to 9%,

In conclusion, it seems that FDG-PET performed early after treatment provides additional information about the efficacy of local tumor ablation by differentiating posttreatment changes from residual or recurrent malignant tumor. This study also provides evidence that FDG-PET has an added value in the detection of tumor recurrence during follow-up. FDG-PET reveals hepatic recurrences in or outside the treated area as well as extrahepatic recurrences earlier than conventional follow-up, ie, CT and CEA measurement.

The present study suggests that FDG-PET may become the primary diagnostic tool to detect local recurrence after CSA or RFA, guiding the determination of whether other imaging techniques are needed (in case of a positive FDG-PET scan). However, larger studies are needed to define the precise impact of FDG-PET as a follow-up measure after local ablative therapy.

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