OBJECTIVE. FDG PET is frequently used as part of the diagnostic workup in cancer patients. Visualization of radiotracer-avid foci suggests the presence of malignant disease. Unexplained focal FDG accumulation in the abdomen is sometimes noted, but the clinical significance of this finding is unknown. Therefore, we followed cases with unexplained focal abdominal FDG uptake found incidentally on whole-body scans to define the cause and clinical significance of this finding.

CONCLUSION. Unexplained focal abdominal FDG uptake is an unusual finding with causes that include malignant and benign processes. Among the 14 cases with definitive diagnoses, seven were adenomas, which is a premalignant condition, and five (35.7%) were malignant. Therefore, although rare, unexplained focal abdominal FDG uptake should not be ignored and further diagnostic workup is warranted.

PET with the radiolabeled glucose analogue FDG is now an established method in the diagnosis and staging of many malignancies. FDG PET is also used for early prediction of a response to treatment and the detection of recurrent disease [1–3]. In cancer, the accumulation of FDG in tumor tissue is related to the rate of cellular glucose metabolism and the malignant potential of the tissue [4]. However, FDG accumulation is not specific for malignancies; this finding can also be caused by infectious or inflammatory processes [5]. In addition, a number of normal variants in FDG accumulation have been described, including uptake in the myocardium, stomach, normal skeletal muscles, and brown fat tissue [6, 7]. Radiotracer uptake by these organs is variable and can sometimes interfere with the detection of true lesions. Excreted radiotracer in the kidneys and ureters can also interfere with interpretation.

FDG uptake in the small intestines and colon is variable and has been related to smooth-muscle activity, constipation, and the presence of lymphoid tissue [6, 8]. However, the exact mechanism and cause of the intestinal FDG uptake are still uncertain. Within the large intestine, increased FDG accumulation is frequently observed in the cecum, ascending colon, and rectosigmoid region when compared with other bowel segments [9, 10]. Patterns and intensity of FDG uptake in the colon and their relationship to patient symptoms have been studied previously [10]. Physiologic FDG uptake in the intestines or uptake related to inflammatory conditions, such as colitis, can be identified when it follows the contour of the gastrointestinal tract, appears curvilinear, and is diffuse [11, 12]. However, more prominent and focal radiotracer accumulation is sometimes seen. Such focal FDG uptake in the colon has been linked to the presence of adenomas [13–17]. The studies are either case reports or reports about the patterns of uptake in the bowel or specifically about the uptake in adenoma. Our study is based solely on focal activity in the abdomen that may or may not be related to the bowel. The incidence and clinical relevance in terms of all possible causes of such incidentally seen focal FDG uptake in the abdomen are not known. We undertook this study to evaluate the significance of this finding.

Materials and Methods

Selection of Studies

One thousand body FDG PET scans obtained over a 1-year period in 1,000 consecutive patients
and interpreted by one physician were included. These studies were performed for staging, treatment evaluation, or follow-up in patients with various malignancies, including melanoma, lung cancer, pancreatic cancer, ovarian cancer, breast cancer, Hodgkin’s lymphoma, head and neck cancer, and colorectal cancer. Patient age ranged from 35 to 82 years. The studies were independently interpreted by a second physician, and the scans for which both reviewers agreed on the presence of unexplained focal abdominal FDG uptake were used for further evaluation of causes. Repeat studies in patients were not included. All scans with focal abdominal uptake that was unexpected were documented. What constitutes unexplained focal abdominal uptake was defined prospectively by criteria. All studies showing focal abdominal FDG uptake at the time of interpretation were recorded for follow-up and later review. Only those studies in which there was no known underlying disease to explain this focal abdominal FDG uptake were used for further analysis and were categorized as unexplained focal abdominal FDG uptake. In contrast, studies in which the focal FDG uptake coincided with the site of a known malignancy were excluded from the analysis.

Patient consent was not obtained because the studies were performed as part of clinical management. However, this analysis was approved by the institutional review board.

**PET Image Acquisition**

All studies were performed using a dedicated PET scanner (Advance, GE Healthcare; or ECAT EXACT HR Plus, Siemens Medical Solutions) The Advance system is operated in 2D mode, has an axial field of view of 15.5 cm, and has a spatial resolution of 4 mm (full width at half maximum intensity [FWHM]) at the center of the field of view. The ECAT EXACT HR plus system (CTi, Siemens Medical Solutions) operates in 3D mode, has an axial field of view of 15.5 cm, and has an axial resolution of 4.1 mm FWHM in the center and 7.8 mm at 20 cm off center. Images were acquired after IV injection of 12–15 mCi (444–555 MBq) of FDG and a 45- to 60-min uptake period. Sequential images extending from the base of the skull to the floor of the pelvis were acquired for multiple bed positions (3-min transmission, 5-min emission per bed position). Iterative reconstruction and segmented attenuation correction were used, and attenuation-corrected images were reviewed.

**Data Analysis**

PET studies that had been selected for later review were interpreted in consensus by two nuclear medicine physicians. Unexplained focal abdominal uptake of FDG was defined as FDG uptake that appeared focal on all three orthogonal projections (coronal, sagittal, and transaxial); was more intense than adjacent bowel and equal to or more than liver activity; and was not in the anatomic position of the urinary tracts, retroperitoneal nodal stations, or any known mass lesion. Diffuse curvilinear FDG uptake was assumed to represent normal or nonmalignant bowel activity and was excluded from the study. Patients with a known abnormality in the area featured on the CT scan were excluded. We used only visual assessment for recognizing the studies with unexplained focal abdominal FDG uptake. No threshold standard uptake value (SUV) was used for identifying these cases. The SUV was calculated for each unexplained focal abdominal FDG uptake focus to assess any significant differences in uptake values between lesions. SUV was assessed semiquantitatively using the region-of-interest analysis and was calculated as maximum activity concentration detected in the lesion divided by the injected activity and corrected for body weight as indicated by the following formula:

$$SUV_{bw} = Q \times W / Q_{inj},$$

where $$SUV_{bw}$$ is standard uptake value normalized to body weight, Q is activity in the lesion measured in megabecquerels per liter, $$Q_{inj}$$ is the injected dose measured in megabecquerels, and W is the patient’s body weight in kilograms.

**Follow-Up and Correlation with Other Imaging Findings**

PET findings were correlated with histopathology if possible. Definitive diagnosis of unexplained focal abdominal FDG uptake was based on histopathology. If histopathology was not available, follow-up clinical data were used to determine a possible cause. Follow-up included clinical symptoms, CT and MRI results, carcinoembryonic antigen (CEA) values, and any surgery or histopathology findings related to the site of uptake that were obtained up to at least 18 months from the date of scanning.

**Statistical Analysis**

The PET findings were correlated with pathology findings to determine the incidence of various findings. Summary statistics were used to describe the distribution of the SUV and size, both for the entire cohort and for benign and malignant lesions. The differences between the SUVs for benign and malignant lesions were evaluated using an exact Wilcoxon’s rank sum test. A p value of less than 0.05 was considered significant.

**Results**

**Description and Verification of Findings**

Twenty foci of unexplained focal abdominal FDG uptake were detected in 16 patients. The final diagnoses, based on surgical findings or histopathology, were available in 14 of 20 foci in 10 patients (Table 1). Two (14.3%) of these 14 lesions were adenocarcinomas (SUV, 12.8 and 13.6, respectively; size, 3×5.5 cm, 2×5 cm, respectively), and seven (50%) were adenomas, of which six were tubulovillous adenomas (SUV range, 3.6–10.9; size range, 0.8–1.5 cm), and one was a tubular adenoma (SUV, 5.2; size, 0.9 cm). An additional three (21.4%) of the 14 unexplained focal abdominal FDG uptake foci were

### Table 1: Patient Data

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Primary Cancer</th>
<th>PET Site</th>
<th>SUV</th>
<th>Pathology Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Breast</td>
<td>Right upper quadrant</td>
<td>12.9</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>Melanoma</td>
<td>Right lower quadrant</td>
<td>3.8</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>Colorectal</td>
<td>Right lower quadrant</td>
<td>16</td>
<td>No evidence of disease at surgery</td>
</tr>
<tr>
<td>4</td>
<td>Prostate</td>
<td>Rectum</td>
<td>3.6</td>
<td>Adenoma, ascending colon</td>
</tr>
<tr>
<td>5</td>
<td>Lung</td>
<td>Celiac</td>
<td>10.9</td>
<td>Tubulovillous adenoma, rectum</td>
</tr>
<tr>
<td>6</td>
<td>Rectal</td>
<td>Right lower abdomen</td>
<td>3.4</td>
<td>NA</td>
</tr>
<tr>
<td>7</td>
<td>Lung</td>
<td>Right upper abdomen</td>
<td>5.2</td>
<td>Tubular adenoma, ascending colon</td>
</tr>
<tr>
<td>8</td>
<td>Breast</td>
<td>Left upper abdomen</td>
<td>9.3</td>
<td>Tubulovillous adenoma, ascending colon</td>
</tr>
<tr>
<td>9</td>
<td>Esophageal</td>
<td>Right lower abdomen</td>
<td>4.8</td>
<td>NA</td>
</tr>
<tr>
<td>10</td>
<td>Ovarian</td>
<td>Right upper abdomen</td>
<td>10.9</td>
<td>Percutaneous metastasis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Left upper abdomen</td>
<td>3.8</td>
<td>Percutaneous metastasis</td>
</tr>
<tr>
<td>11</td>
<td>Paranasal</td>
<td>Left lower quadrant</td>
<td>9.3</td>
<td>No evidence of disease at surgery</td>
</tr>
<tr>
<td>12</td>
<td>Hodgkin’s lymphoma</td>
<td>Mid abdomen</td>
<td>7.2</td>
<td>Tubulovillous adenoma</td>
</tr>
<tr>
<td>13</td>
<td>Rectal</td>
<td>Left lower pelvis</td>
<td>4.8</td>
<td>NA</td>
</tr>
<tr>
<td>14</td>
<td>Colon</td>
<td>Upper mid abdomen</td>
<td>12.8</td>
<td>Adenocarcinoma, duodenum</td>
</tr>
<tr>
<td>15</td>
<td>Pancreas</td>
<td>Lower pelvis</td>
<td>6.7</td>
<td>Tubulovillous adenoma, sigmoid colon</td>
</tr>
<tr>
<td>16</td>
<td>Lung</td>
<td>Right abdomen</td>
<td>13.6</td>
<td>Adenocarcinoma cecum</td>
</tr>
</tbody>
</table>

Note.—SUV = standard uptake value, NA = not available.
peritoneal metastases (SUV range, 3.8–7.8). The remaining two unexplained focal abdominal FDG uptake lesions had no abnormal finding in the area of concern at surgery (SUV, 9.3 and 16, respectively). However, an adenocarcinoma of the colon was later detected at the site of one of the lesions seen on PET. In all patients, the lesions were seen on the PET scan for the first time and there was no known disease at the sites.

In six of the 16 patients with unexplained focal abdominal FDG uptake for whom histopathology was not available, concurrent CT of the abdomen showed no evidence of disease. During the follow-up period of 18–24 months, one patient died from other causes (within 6 months) and the other five patients did not have any signs or symptoms referring to the site of abdominal uptake. None underwent colonoscopy, and no definite cause for abnormal abdominal uptake could be determined in these patients.

SUV Analysis

The SUV of all the lesions varied between 3.4 and 16, with a mean ± SD of 7.62 ± 3.74. The size of the lesions ranged from 0.9 to 5.5 cm. The average size of the benign lesions was 1.4 cm with a range of 0.9 to 2.5 cm, and the average SUV was 7.0 ± 3.0 (range, 3.6–10.9).

There were five malignant lesions: three peri- toneal metastases and two adenocarcinomas. The average SUV for the malignant lesions was 8.4 ± 4.7 (range, 3.8–13.6). In total, 12 (85.7%) of 14 lesions had a malignant or premalignant (tubular and tubulovillous adenoma) cause.

The SUV for the two lesions for which no evidence of disease was seen at surgery was 9.3 and 16. Adenocarcinoma was detected 1 year later in one of these sites (SUV, 16) (Table 1).

The SUV for the lesions for which no specific cause could be determined ranged between 3.4 and 12.9, with a mean of 5.67 ± 3.59.

Statistical Analysis

The SUVs for benign and malignant lesions were compared using an exact Wilcoxon’s rank sum test. No significant difference in the SUV for benign versus malignant lesions was detected ($p = 0.43$).

Discussion

Physiologic uptake of FDG is frequently seen in the abdomen and can be related to variable bowel uptake or focal stasis of excreted radiotracer in the ureters [6–9]. Pathologic uptake of FDG in the intestine can present in a pattern that is focal (e.g., tumor or polyp), segmental (e.g., Crohn’s disease or normal variant), or diffuse (e.g., colitis). Segmental or diffuse uptake is easily identified in the three orthogonal planes. Sometimes focal abdominal FDG uptake, which can be localized to bowel on review of the three orthogonal planes, is noted as an incidental finding. Interpretation of abnormal focal uptake on PET without CT correlation is difficult, and the exact location and cause of this finding often remain uncertain.

Incidental FDG Uptake on PET: Comparison with Previous Studies

Unexpected or incidental FDG uptake in different areas of the body on PET has been described previously. Sometimes primary or secondary malignancies are detected when scanning is performed for another purpose [17–21]. Previous studies and case reports have documented incidental FDG uptake in the colon as related to the patient’s symptoms, infections of the gastrointestinal tract, and colonic adenomas [10–16], and some have also addressed the clinical significance of this finding. In a study by Zhuang et al. [17], incidental focal FDG uptake was noted in the colon in 17 of 197 patients with lung nodules. Fourteen underwent colonoscopy, and biopsy showed five carcinomas and one colonic adenoma. Tatlidil et al. [22] described various patterns of increased FDG uptake in the colon in 80 of 3,000 PET studies with final diagnosis in 27 patients. In those who had nodular focal or nodular multifocal pattern of FDG uptake, premalignant or malignant lesions were seen in all patients (100%), with 46% of the cases related to primary or metastatic malignancies, whereas no premalignant or malignant lesions were seen in those with diffuse pattern of uptake.

All the prior studies described the collective patterns of incidental or abdominal focal FDG uptake. However, our study focused specifically on the causes and the clinical significance of focal abdominal FDG uptake alone. It is important for the interpreting physician to be familiar with many normal variants in FDG distribution throughout the body [9], including the abdomen. However, focally increased FDG uptake probably has the greatest clinical relevance because this pattern of uptake is more likely to be caused by tumors or polyps rather than by inflammation. Therefore, our study addresses this particular pattern of abdominal FDG uptake.

Clinical Significance

We found a low incidence of unexplained focal abdominal FDG uptake (16/1,000 scans or 1.6% of cases). One half (7/14 [50%]) of all unexplained focal abdominal FDG uptake lesions with definitive diagnoses were tubulovillous or tubular adenomas (Fig. 1). The original diagnoses in these patients were prostate, lung, paranasal, and colorectal cancer. Adenomatous polyps, although benign, are known to be precursors of colon cancer and form the most common neoplasm of the large bowel. The prevalence of adenomas increases with patient age and is approximately 25% at the 50 years and 50% at age 70. Histologically, adenomas are grouped as tubular, forming 75% of all the polyps, and as tubulovillous and villous, forming 15% and 10% of all neoplastic polyps, respectively [23, 24]. Adenomas are considered premalignant conditions with a malignancy rate of approximately 5% for tubular, 22% for tubulovillous, and 40% for villous adenomas. The malignant potential increases with the size of the lesion.

Intraluminal polyps and other small tumors are frequently not seen on the standard CT scan. FDG PET may offer some advantage in their detection. In addition, intestinal lesions detected on FDG PET are likely to be at least 8–10 mm and therefore may have a greater risk of malignancy.

Of note in our study is that a large fraction of the total foci of unexplained focal abdominal FDG uptake for which follow-up was available (3/14 lesions [21.4%]) were malignant tumors or metastases that were unknown at the time of PET. Of these lesions, three foci were peritoneal metastases not detected on CT (Fig. 2) and two foci were found to be adenocarcinoma of the intestines, later confirmed on colonoscopy. The two adenocarcinoma lesions were unrelated to the original primary cancer (one lung cancer and one colon cancer).

In one patient with primary colon cancer, a PET scan obtained for follow-up of recurrent disease showed disease in the liver in addition to unexplained focal abdominal FDG uptake in the right lower abdomen. At surgical exploration, no evidence of disease was detected. However, follow-up, consisting of CEA levels and CT scans, detected adenocarcinoma at the site, and this finding was confirmed at surgery 1 year later. Surgical confirmation 1 year later suggests that the finding on the PET scan was likely true-positive and that this true-positive finding was not detected at prior surgical exploration.

In six patients, there was no definable lesion because colonoscopy was not performed and, therefore, no histopathology was available. Because the definite diagnosis can be made only with histopathologic correlation, the presence or absence of lesions cannot be fully ascertained when this information is not available. Also, lesions such as adenomas may be difficult to detect on a CT scan and may be clinically silent for years. Therefore, although no clinical symp-
symptoms or obvious lesions on CT scans were seen in these patients during the follow-up period, it cannot be concluded that there was no underlying lesion. Only colonoscopy could ascertain the presence or absence of lesions.

Quantitative analysis using SUVs showed wide overlap in the intensity of radiotracer uptake between benign and malignant lesions, and no significant difference was seen in the uptake value for both \( p = 0.43 \). Therefore, distinction of malignancy in unexplained focal abdominal FDG uptake lesions using the SUV alone is probably not possible.

Rather than just observational, our findings are of distinct clinical significance. Although uncommon, focal FDG uptake in the abdomen should not be ignored during study interpretation. Because surgical resection of colonic adenomas is considered an accepted medical practice in the prevention of cancer [25] and because of the high incidence of premalignant and malignant conditions in unexplained focal abdominal FDG uptake (12/14 lesions in this study), further diagnostic workup is indicated.

We agree that the incidence of incidental unexplained focal abdominal FDG uptake may vary among reviewers. We have provided the specific criteria that were used for interpretation. The standard for what constitutes an unexplained focal abdominal FDG uptake is therefore only subjective insofar as other physicians may use other criteria. However, the criteria used in this study take full advantage of 3D PET image display and account for a number of normal variants in bowel activity, which are mostly segmental, not focal, and excreted FDG in the urine. In fact, normal bowel uptake of FDG can vary in intensity, but the character of the uptake—focal versus linear—appears to be at least as important as intensity. We therefore think that our criteria are reasonable to address this question. In fact, daily clinical practice shows that what may appear focal in one projection may not appear focal once additional projections are reviewed. Hence, our criteria

![Image](https://www.ajronline.org)

**Fig. 1.**—75-year-old man with nasopharyngeal carcinoma (patient 11 in Table 1). A and B, Coronal (A) and sagittal (B) PET and PET/CT fusion images show focal FDG uptake (arrow, A) in left hemipelvis. C and D, Transaxial PET/CT fusion images localize this abnormality to sigmoid colon. Histopathology showed tubulovillous adenoma.
probably reduce the subjective element in image interpretation. Overall, the pattern was well recognizable using these criteria.

With the recent advent of combined PET/CT, unexplained focal abdominal FDG uptake may be localized better to the bowel, the peritoneum, or lymph nodes (Fig. 1). Nevertheless, determination of their cause based on imaging alone may remain elusive. In some cases, colonoscopy and biopsy may be necessary to address the findings.

In conclusion, focal accumulation of FDG in the abdomen that is not sufficiently explained by the primary disease is an unusual finding whose cause includes both malignant and benign processes that may not be related to the bowel or the primary cancer. In our study, 12 (85.7%) of 14 lesions were either premalignant or malignant in origin. Although rare, the finding should not be ignored and warrants further diagnostic workup.

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