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Frequency and etiology of solitary hot spots in the pelvis at whole-body positron emission tomography/computed tomography imaging, ☆,☆☆

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Abstract

Purpose—To determine the frequency and etiology of a single hypermetabolic focus within the pelvis with no other areas of increased 18-fluorodeoxyglucose (FDG) uptake in the remainder of the whole body in an oncological population.

Method and Materials—We retrospectively examined the first 700 whole-body PET/CT scans performed at our institution for baseline staging or follow-up of cancer and identified all patients with a solitary focus of increased FDG uptake in the pelvis. All available medical records and imaging findings in these patients were reviewed in order to determine the etiology of increased FDG uptake.

Results—Eight (1.1%) of the 700 patients had a solitary hot spot in the pelvis at positron emission tomography (PET)/computed tomography (CT) imaging, consisting of seven of 380 women and one of 320 men. In the seven women, increased FDG uptake was due to physiological endometrial uptake ($n=2$), leiomyoma ($n=1$), corpus luteum cyst ($n=1$), physiological ovarian uptake ($n=1$), urinary leak ($n=1$), and nonspecific colitis ($n=1$). In the man, uptake was due to recurrent rectosigmoid adenocarcinoma. None of the 700 patients was found to have metastatic disease in the pelvis.

Conclusion—Isolated pelvic hot spots at PET/CT imaging in an oncological population are not common and usually benign; physiological endometrial or ovarian uptake is the single commonest cause.

Keywords

¹⁸F-FDG; PET Scan; Helical CT; Pelvis

1. Introduction

Over the last 20 years, positron emission tomography scanning with 18-fluorodeoxyglucose (FDG) has become an important imaging tool in the detection and surveillance of cancer [1–3]. More recently, the introduction of positron emission tomography (PET)/computed tomography (CT) has provided an opportunity to simultaneously evaluate both the metabolic and anatomic features of disease, with CT allowing for improved anatomic localization and

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characterization of focal increased FDG uptake. While multifocal increased FDG uptake is very typical of disseminated malignancy, particularly given that cancer is the primary indication for PET scanning, solitary FDG hot spots can be more problematic. This problem has been described in PET studies of the abdomen [4], where seven of 14 such hot spots were due to benign colonic adenomas. Given that physiological and incidental pathological causes of increased FDG uptake are likely to be encountered in the pelvis, particularly in women [5–8], it seems plausible that such hot spots in the pelvis are also likely to be relatively common and unrelated to metastatic disease. To our knowledge, this question has not been studied. Therefore, we undertook this study to determine the frequency and etiology of a single hypermetabolic focus within the pelvis with no other areas of increased FDG uptake in the remainder of the whole body.

2. Materials and methods

2.1. Subjects

This was a retrospective single institutional study approved by our Committee on Human Research with waiver of the requirement for informed consent. The study was compliant with requirements of the Health Insurance Portability and Accountability Act. We performed a computerized search of our radiology information system (IDXrad, software version 9.7.1, IDX Systems, Burlington, VT, USA) to identify the first 700 PET/CT studies performed at our institution after January 2003. These 700 studies were performed on a total of 448 patients. These 700 cases consisted of 380 studies in 234 women and 320 in 214 men. The patient mean age was 53.6 years (range, 6 to 86 years). The indications for PET/CT scanning were baseline evaluation of newly diagnosed malignancy ($n=135$) or restaging of malignancy after therapy ($n=565$). Primary cancer sites were lymphoma ($n=93$), breast ($n=72$), lung ($n=54$), melanoma ($n=45$), gynecologic organs ($n=30$), colon ($n=28$), bone/soft tissue ($n=28$), head and neck ($n=27$), miscellaneous ($n=27$), unknown primary cancer ($n=17$), gastroesophageal ($n=13$), renal ($n=5$), hepatocellular ($n=3$), pancreatic ($n=3$), and desmoid ($n=3$).

2.2. Imaging technique

All ^{18}F -FDG PET/CT studies were performed on a Siemens Biograph 16 (Hi-Rez) PET/CT scanner (Siemens Medical Solutions USA, Inc., Malvern, PA, USA), which is a hybrid PET and 16-slice multi-detector row CT. Patients fasted for at least 6 h prior to the PET/CT scan. Diabetic patients were instructed to follow a low carbohydrate diet the evening before and withhold all insulin for 4 h preceding the PET/CT exam. Blood glucose level was checked by the fingerstick method prior to injection of the radiopharmaceutical. Intravenous injection of 12.5 ± 2.5 mCi ^{18}F -18 fluoro-2-deoxyglucose (^{18}F -FDG) was followed by a 10-ml normal saline flush. Patients rested for 60 ± 15 min and voided prior to being positioned supine on the scanner table-top. CT was performed before PET, at 152 mA s, 120 kV, and 0.75 mm collimation width, and reconstructed as contiguous 5-mm slices. Images were obtained from the top of the head to the feet in patients with melanoma or lower extremity tumors, but stopping at mid thighs for patients with other primary cancers. A volume of 150 ml of intravenous iohexol (Omnipaque 350; Nycomed Amersham, Princeton, NJ, USA) was administered 70 to 80 s prior to the CT scan at a rate of 3 ml/s and followed by a 50-ml saline flush using a power injector (Stellant D; Medrad, Inc., Indianola, PA, USA). PET was performed immediately after CT, without repositioning. PET images were obtained at 7–10 stations per patient, with an acquisition time of 4 min per station, from the top of the head to the feet or mid thighs. The CT data was used for attenuation correction of PET emission images, which were then co-registered with CT images. The reconstructed CT, PET, and fused PET/CT images were displayed in axial, sagittal, and coronal planes. Ninety-one (13%) of 700 CT scans were acquired without intravenous injection of iodinated contrast material per request of the referring physician, or due to history of contrast allergy or decreased renal function.

2.3. Image interpretation

All cases were reviewed by one of the authors (__) using our picture archiving and communication system workstation (Impax; Afga, Morsel, Belgium) and a dedicated PET image-processing workstation (Leonardo, Siemens Medical Solutions). Images were also correlated with the finalized reports. Those in which a single focus of increased FDG uptake was found in the pelvis in the absence of any other foci within the body were identified. Because standardized uptake value (SUV) is a semiquantitative index for FDG uptake and because the use of contrast enhanced CT for attenuation correction can affect the calculation of SUV [9], we opted to use visual inspection rather than an absolute SUV to define a hypermetabolic focus. A solitary pelvic hot spot was considered present in the pelvis if there was an unequivocal focus of abnormal FDG activity (i.e., not attributable to normal activity in the bowel, bladder, or ureter), and no other abnormal foci of FDG activity was seen elsewhere in the body. We used hepatic FDG uptake as an internal reference. SUVs of each pelvic hypermetabolic focus were measured for descriptive purposes.

2.4. Standard of reference

Medical charts and follow-up imaging studies (including ultrasound, CT, MRI, and PET/CT) of all cases with a single hypermetabolic focus within the pelvis with no other areas of increased FDG uptake in the remainder of the whole body were reviewed by one of the authors (__). A benign etiology was determined by (1) histopathology, (2) resolution in subsequent imaging studies without interval treatment, (3) stability on follow-up studies acquired at least 6 months later, and (4) typical appearance of anatomical/physiologic structures on imaging [10,11]. Malignancy was determined based on histopathology or evidence progression of disease on follow-up studies.

3. Results

Eight (1.1%) of the 700 cases had a solitary hot spot in the pelvis at PET/CT imaging. Seven of these hot spots were identified in women and one in a man. The mean SUV of these eight spots was 4.8 (range, 2.8–6.4). In five of the seven women the isolated pelvic hot spot was related to physiologic uptake within the female reproductive organs with an overall incidence of 0.7% and a female-specific incidence of 1.3% (Figs. 1 and 2). A single case of isolated malignant uptake, due to locally recurrent rectal cancer, was identified. None of the 700 patients was found to have metastatic disease in the pelvis. These results are further detailed in Table 1.

4. Discussion

The advent of PET/CT imaging has improved baseline staging and surveillance for disease recurrence in cancer patients. The ability to co-register the anatomical data of CT with the functional data of PET in a hybrid PET/CT image provides diagnostic information unmatched by either modality alone. PET/CT imaging also has some specific pitfalls related to abnormal foci of FDG uptake, including correction artifact; physiological uptake in muscle, fat, or bowel; and nonmetastatic uptake in inflammation or benign tumors [12–15]. We demonstrate in our large series of cases that isolated pelvic hot spots have an overall incidence of 1.1% (8/700), with the majority (5/8 or 62.3%) being due to physiological or benign uptake in female reproductive organs. It may be possible to minimize physiologic FDG uptake in the uterus and ovaries by understanding how this uptake relates to the stages of the menstrual cycle or to reproductive hormonal shifts. Further understanding of such phenomena can prove useful in detecting pelvic tumors accurately in females where detection would be otherwise confounded by the presence of benign pelvic hot spots. For example, women could be scheduled for PET/CTs during the secretory phase of their cycle to minimize uterine uptake or during the

proliferative phase of their cycle to minimize corpus luteal cyst uptake. Other isolated pelvic hot spots on PET/CT such as uptake in inflamed bowel or within leaked urine are more difficult to address systematically and likely require a case-by-case approach with knowledge of detailed clinical history (i.e., Crohn's disease patient with active disease, leukocytosis, etc.) and/or notes from the radiology technologist (i.e., patient with leaked urine during the examination).

Irrespective of the considerations above, one clear result of our study is that solitary pelvic hot spots appear unlikely to represent metastatic disease. We had only one case (1/8, 12.5%) of malignant disease in our series, but not related to metastases. This is an important result that may provide reassurance to an anxious patient and allow for a more conservative approach to the work-up of such a finding. It is also worth noting that an isolated pelvic hot spot might give rise to greater concern in community practice, where PET/CT studies are often performed without intravenous iodinated contrast. The ability to recognize benign uptake in a fibroid or corpus luteum cyst may be very limited in this scenario, and the reassurance provided by our study would then become even more important. While we cannot conclude that a solitary pelvic hot spot will never be due to metastatic disease, such an occurrence would seem rare, given that we did not see this once in 700 cases. It is important to note, though, that in patients with colorectal cancer, and conceivably with other primary malignancies arising in the pelvis, the likelihood of an isolated hypermetabolic focus in the pelvis being local recurrence or residual tumor may be relatively higher when compared to other malignancies.

Our study has some limitations. First, this was a retrospective study with all inherent limitations of such a design. Second, the research was done at a single tertiary institution with a population that may not reflect the general population; however, our findings were mostly related to physiologic changes and uterine leiomyomas rather than rare pathologic conditions or specialized treatments. Third, we did not stratify patients based on their initial diagnosis, but pooled all into one group. It is conceivable that within certain group of patients, for instance, a patient with a primary anorectal cancer, an isolated hot spot would more likely represent malignancy rather than a benign hot spot. The fact that we identified only one case of isolated malignant focus may be explained by our research design. On the other hand, our large sample size probably mitigates any detrimental effects of this bias. Fourth, we had only one reader reviewing all images and that precludes any assessment of interobserver variability. Although this may be a significant limitation on research assessing the accuracy of a diagnostic method, it is less likely to have a major impact on a descriptive study. In addition, it is conceivable that the single reader missed an isolated hot spot within the pelvis that would have been otherwise detected by a second radiologist. This is felt to be unlikely as there were three independent opportunities to identify such findings: the PET images, the CT images, and the related report. Fifth, our definitions of hot spot did not use any strict SUV numbers. SUV measurements are, however, subject to variability due to physiological aspects (such as blood glucose level, body habitus, and organ of interest) and measurement variability, including camera calibration, time of scanning postinjection, size of regions of interest, and choice of backgrounds. Irrespectively, the use of a minimal SUV threshold to establish the presence of an isolated hot spot would not have changed the conclusions of this study, as we would not have increased the number of malignant lesions identified. In summary, understanding the incidence and radiologic appearance of isolated hot spots in PET/CT imaging is pivotal in accurate diagnosis of malignant vs. benign disease. Our results show that isolated pelvic hot spots at PET/CT imaging in an oncological population are not common and usually benign; physiological endometrial or ovarian uptake is the single commonest cause.

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Fig. 1.

PET/CT images of a 27-year-old female with history of non-Hodgkin's lymphoma. Axial PET scan image (A) shows focal ¹⁸F-FDG uptake in the pelvis that corresponds to the endometrial cavity on the axial contrast enhanced CT image (B) (arrows). Although a slight mismatch is present, the fused PET/CT image (C) confirms the location of the uptake within the endometrial cavity (arrow). No endometrial ¹⁸F-FDG uptake is identified on a follow-up PET/CT scan (D) (arrow).

Fig. 2. PET/CT images of a 41-year-old female with history of breast cancer. Axial PET scan image (A) shows focal ¹⁸F-FDG uptake in the pelvis that corresponds to a corpus luteum cyst on the axial contrast enhanced CT image (B) (arrows). The fused PET/CT image (C) confirms the location of the uptake within the left ovary (arrow).

Table 1
Demographics and detailed results on eight patients with isolated pelvic uptake

	Gender	Age	Primary diagnosis	Hot spot diagnosis	SUV	Standard of reference
1	F	41	Breast cancer	Ovary	6.4	Typical appearance on contrast enhanced CT
2	F	57	Cervical cancer	Leiomyoma	2.8	Typical findings on follow-up MRI+stability on follow-up PET/CT
3	F	27	Non-Hodgkin's lymphoma	Endometrium	5.3	Resolution on PET/CT without treatment
4	M	47	Rectal cancer	Recurrent cancer	4.0	Histopathology
5	F	35	Melanoma	Urinary leak (incontinence)	4.5	Clinical history+resolution on PET/CT
6	F	42	Hodgkin's disease	Endometrium	5.9	Stability on follow-up PET/CT+CT
7	F	66	Vulvar cancer	Nonspecific colitis	5.7	Clinical findings (diarrhea)+resolution on CT
8	F	43	Right ovarian mass	Corpus luteum (left)	4.1	Typical appearance on contrast enhanced CT