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PET and PET–CT imaging findings of peritoneal and omental involvement in patients with lymphoma

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ABSTRACT

A retrospective institutional-review-board-approved study was performed evaluating positron emission tomography (PET)–computed tomography (CT) imaging findings of peritoneal and omental involvement of lymphoma. Twelve patients were identified with a wide spectrum of imaging findings on PET–CT including but not limited to peritoneal thickening, ascites, and serosal involvement. Lymphoma is among the rare causes of malignant peritoneal or omental involvement. The most common manifestations of peritoneal lymphomatosis are peritoneal 2-[fluorine 18] fluoro-2-deoxy-D-glucose uptake with corresponding peritoneal thickening and nonobstructive serosal masses on CT.

1. Introduction

The peritoneum is the largest serous membrane of the body and the preferred site of metastasis in the course of several malignancies. Indeed, almost all malignancies are known to metastasize to the peritoneum, but peritoneal carcinomatosis principally occurs in the settings of colorectal carcinoma in men and ovarian tumor in women. Other malignancies with this propensity include gastric, pancreatic, and adrenocortical carcinoma [1]. Early diagnosis of peritoneal involvement is crucial for accurate staging and for treatment planning because, with an early diagnosis, unnecessary laparotomies or other futile therapeutic interventions may be prevented [2,3].

Cross-sectional imaging is regarded as a mainstay in the diagnosis of peritoneal carcinomatosis and omental tumor involvement; however, several pitfalls for diagnosis exist [4]. Peritoneal involvement may be hard to assess with conventional computed tomography (CT), magnetic resonance (MR), and ultrasound (US) imaging, and their diagnostic sensitivity ranges widely between 17% and 91%. CT has known limitations in the assessment of low-volume peritoneal neoplastic involvement, performing worse in the pelvis [1]. It can also sometimes be difficult to recognize even more sizable peritoneal disease on CT scans due to their similar size and appearances to adjacent bowel loops. MRI, despite sometimes delineating small peritoneal deposits as small as 3 mm, is overall no better than CT [1,5,6].

Lymphoma may manifest in the abdomen most characteristically as solid organ nodules or bulky retroperitoneal lymphadenopathy, but it is among the rarer causes of peritoneal malignant involvement. Indeed, the imaging features of peritoneal lymphomatosis are scarce in the radiology literature [7,8]. This is because there is an absence of lymphoid tissue in the omentum. The mode of dissemination to the omentum is thought to be through intraabdominal ligaments and visceral peritoneal surfaces, similar to other gastrointestinal malignancies [9].

Given that most lymphomas are generally metabolically active, 2-[fluorine 18] fluoro-2-deoxy-D-glucose (FDG) positron emission tomography (PET) is very useful for diagnosis and staging of lymphoma [10]. There are many studies that prove the sensitivity of PET–CT in patients with Hodgkin's lymphoma (HL) and high-grade or aggressive non-Hodgkin's lymphoma (NHL) [11]. PET–CT may be useful for the evaluation of lymphomatous peritoneal neoplastic infiltration as outlined by some published studies for other malignancies [1]. In this presentation, we aim to outline the use of FDG-PET–CT in the detection of peritoneal involvement of HL and NHL.

2. Materials and methods

An institutional-review-board-approved retrospective study was performed with waiver of informed consent. Our electronic database was searched to identify patients with HL and NHL who had omental and peritoneal involvement by imaging or pathology. The demographics and the types and subgroups of lymphoma were also recorded. The PET–CT images of these patients were retrieved from the digital archive system and were reevaluated.

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All patients fasted for at least 6 h prior to image acquisition. Twenty ounces of a 0.1% barium sulfate suspension was administered as a low-density oral contrast material 1 h prior to scanning. Fifteen millicuries (555 MBq) of FDG was then administered intravenously 45 min to 1 h before scanning. Imaging was performed with either a 16-slice or 64-slice hybrid PET/CT (Biograph 16 or 64; Siemens, Erlangen, Germany, and 64-slice GE Discovery; Milwaukee, WI, USA). An initial, low-radiation-dose CT was then performed primarily for attenuation correction with patients in midexpiration respiratory phase (suspended breath hold) and extended from the external auditory meatus to below the symphysis pubis (section thickness: 5 mm, table feed per rotation: 18 mm, time per table rotation: 0.5 s, field of view: 70 cm, tube voltage: 120 kVp, tube current: 11 mA). PET images were acquired in a three-dimensional mode, and sufficient bed positions were used to image from the skull base to midthigh. Scan-bed acquisition time was usually 3 min per bed position to up to 7 min in obese patients. Images were reconstructed at 2.4-mm section thickness.

Diagnostic quality contrast-enhanced CT was then performed after the PET acquisition with 100 ml of 300 mg iodine per milliliter followed by 20 ml saline injected by using a dual-head injector. The injection rate was 2 ml/s with a 60-s postinjection delay with breath hold and extended from the external auditory meatus to the midthigh (section thickness: 5 mm, table feed: 15 mm/s, pitch: 1.5, tube voltage: 120 kVp, effective tube current–time product: 200 mA). Images were then reconstructed with 2-mm section thickness at 2-mm intervals.

All CT studies were obtained at portal venous phase, except for two patients with mantle cell lymphoma and posttransplant Burkitt's lymphoma, respectively, who did not receive intravenous (IV) contrast. Coronal and sagittal reformatted images were also available in all patients. The images were reviewed by two radiologists (A.K. and M.B.) in consensus. The images were evaluated for the presence of ascites, serosal involvement, omental and peritoneal masses, solid organ involvement, and retroperitoneal and mesenteric lymphadenopathy.

Peritoneal and omental involvement was concluded when bulky solid lesions or nodular infiltration was seen on diagnostic CT or abnormal FDG uptake was present on PET. A patient was decided to have a positive PET scan if the maximum standardized uptake value (SUV) was greater than 2.5. The lymph nodes were considered to be enlarged when their short axis exceeded 8 mm. The solid organ involvement of the liver, kidney, spleen, and adrenal glands was also evaluated.

The clinical follow-up of the patients was also recorded using our hospital's electronic medical records.

3. Results

We identified 12 patients with several subtypes of lymphoma. Eight patients were male, while four were female, with an average age of 53 (range, 32–73) years. All patients' diagnoses were pathologically proven with either a bone marrow biopsy or a solid organ biopsy including lymph nodes. The subtypes of the lymphomas are reported in Table 1. All our patients had advanced-stage lymphoma and were treated with chemotherapy regimens following protocols.

Table 1
Distribution lymphoma subtypes in patients

Lymphoma subtype	Number of the patients (total=12)
DLBCL	9 (75%)
Posttransplant Burkitt's lymphoma	1 (8.3%)
HL	1 (8.3%)
Mantle cell lymphoma	1 (8.3%)

Table 2
Imaging findings of the patients with lymphoma

Imaging findings	Number of patients (total=12)
Peritoneal thickening and FDG uptake	11 (91.6%)
Serosal mass	6 (50%)
Ascites	3 (25%)
Mesenteric mass	3 (25%)
Retroperitoneal lymphadenopathy	3 (25%)
Solid organ involvement	1 (8.3%)

There was a wide spectrum of imaging findings (Table 2). Eleven of the patients had some degree of peritoneal thickening on CT, and all had correlative FDG uptake on PET imaging. The essentially negative CT case had only a mild increase in fat density to correspond to the abnormal FDG uptake. The morphologic appearance of peritoneal involvement was highly variable, including mild irregularity, haziness, and thickening and pronounced nodularity (Fig. 1). Mass-forming peritoneal lesions were detected in three patients (Fig. 2). PET images demonstrated focal or diffuse FDG uptake in the peritoneum in all patients but one. Follow-up was available for all the patients and ranged from 3 months to 5 years (mean, 15.6 months). Three of the patients passed away (4, 5, and 16 weeks after

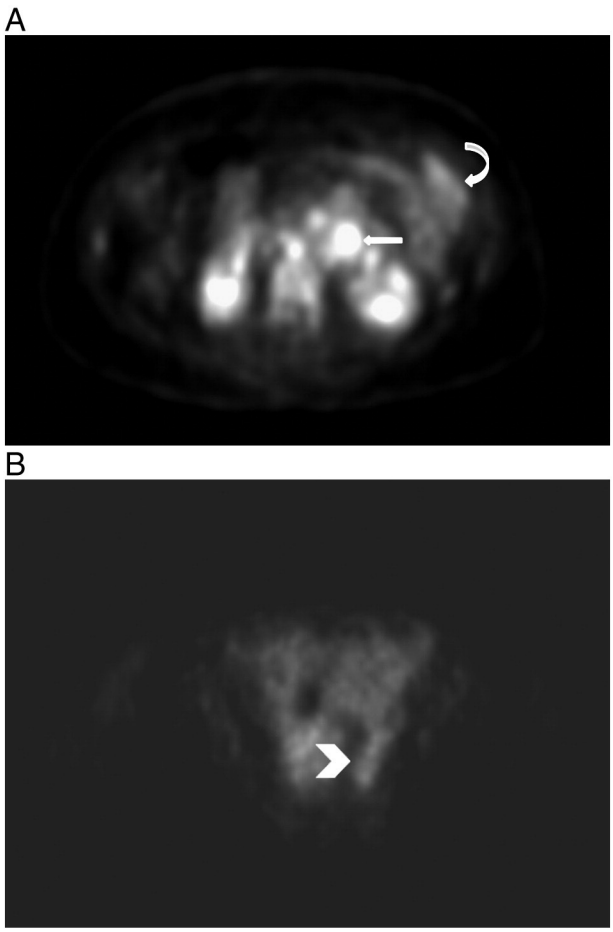

Fig. 1. (A, B) Different forms of peritoneal involvement in two patients with DLBCL. Mild haziness and thickening in the left paracolic gutter (curved arrow) with associated paraaortic lymphadenopathy were observed on the CT scan (not shown). Corresponding axial PET image (A) demonstrates FDG avidity in these lesions (curved and straight arrows). Axial image from a PET scan (B) in another patient with DLBCL and diffuse nodularity in the left pelvic peritoneum on CT (not shown) shows FDG avidity in the corresponding region (arrowhead). These findings completely regressed on follow-up PET–CT scans. Both patients are in complete remission at the time of the completion of this study.