REVIEW ARTICLE

Utility of positron emission tomography/CT in the evaluation of small bowel pathology

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ABSTRACT. We describe the management principles and different roles of positron emission tomography (PET)/CT in the evaluation of patients with small bowel tumours (adenocarcinoma, gastrointestinal stromal tumour, lymphoma, metastases) from initial staging, monitoring response to treatment, to detection of recurrent disease. We also discuss the various non-malignant aetiologies of small bowel fludeoxyglucose (FDG) PET uptake, and other pitfalls in FDG PET/CT interpretation. Awareness of the imaging appearances of small bowel tumours, patterns of disease spread and potential PET/CT interpretation pitfalls are of paramount importance to optimise diagnostic accuracy.

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Cancers of the small intestine (including adenocarcinoma, lymphoma, sarcoma and carcinoid) account for less than 5% of all gastrointestinal malignancies [1]. Patients with small bowel tumours usually present with non-specific gastrointestinal symptoms and, owing to delayed diagnosis, may present in the later stages of disease. Thus, accurate disease staging is of importance to guide appropriate treatment.

Fludeoxyglucose (FDG) positron emission tomography (PET) is an important tool in oncological patient management, and may play a significant role in disease staging, restaging and monitoring response to treatment. The purpose of the review is to demonstrate the PET/CT imaging features of local and metastatic small bowel tumours, to show PET/CT's value in disease detection and characterisation, and to highlight imaging pitfalls that may be encountered.

Technique

Patients are fasted for a minimum of 4 h prior to imaging. After receiving the FDG intravenous injection, patients consume 1350 ml of low-attenuating oral contrast over 45 min. While waiting the 60 min between FDG administration and subsequent imaging, patients are encouraged to rest and activities such as talking, chewing and walking are restricted. Thereafter a low-radiation-dose unenhanced CT (primarily for attenuation correction) is first performed. Then the PET data are acquired, followed immediately by a fully diagnostic standard radiation dose intravenous contrast-enhanced CT (CECT)

with the previously administered water attenuation oral contrast outlining the gastrointestinal tract.

Value of oral contrast

Oral contrast agents distend the bowel, which increases the conspicuity of bowel luminal, mural and extraluminal disease, and may improve the manifestation of bowel disease, adjacent mesenteric and retroperitoneal metastatic deposits, as well as facilitate identification of synchronous small bowel and colonic lesions. Non-specific intestinal FDG uptake of moderate degree may be encountered in PET and PET/CT imaging [2–5] and is thought to be due to peristalsis, bowel mucosal structures, lymphocytic cell concentration or intestinal bacteria [2, 3]. Oral contrast may aid in the evaluation of this, as distending these segments at CT may negate the effect and simultaneously allow confident exclusion or diagnosis of luminal or mural disease. Blake et al [2] found that bowel loops distended with oral contrast demonstrated less FDG PET uptake with lower standardised uptake value (SUV) levels.

The main limitation is the effect of high-density oral contrast on attenuation correction. High-density barium can produce reconstruction artefacts that result in high FDG uptake due to inconsistencies in attenuation correction. This phenomenon can arise following contrast desiccation in the right colon, resulting in concentrated barium [3, 6, 7]. This artefact can be identified by review of the non-attenuation-corrected images, which should not demonstrate the artificially high FDG. Automated segmentation algorithms are currently being developed to address this problem, and indeed this artefact can be reduced by using a low- or neutral-density contrast such as low-density barium [2, 6],

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Gastrografin 8 ml per 500 ml water [2] or 0.2% locust bean gum and 2.5% mannitol [7], which has been shown not to significantly affect attenuation correction. The benefits of such low- or neutral-density oral contrasts are greatly increased by the concomitant administration of intravenous contrast [8]. Intravenous contrast is also helpful for primary and secondary lesion identification, degree of enhancement and relationships to vessels.

Small bowel tumours

Small bowel adenocarcinomas account for 1–2% of all gastrointestinal tract neoplasms [1] and 30–40% of all primary small bowel tumours [9]. The majority arise in the duodenum and jejunum, with the exception of patients with Crohn's disease, in whom the most common site is the terminal ileum.

Management of patients with small bowel adenocarcinoma is dependent on disease location and stage as determined by imaging and laparoscopy. Surgical resection is the treatment of choice and provides the only hope for cure for adenocarcinoma of the small bowel. Patients with metastatic disease undergo resection in most cases to prevent later complications such as obstruction. Veyrières et al [10] reported an overall 5-year survival of 38%; with palliative treatment alone the 5-year survival was 0%, while it was 54% after curative resection. In patients undergoing curative resection, the 5-year survival was 63% when lymph nodes were not involved and 52% when they were, 57% when the serosa was not involved and 53% when it was, and 56% when the tumour was well or moderately well differentiated and 40% when it was undifferentiated [10]. Other factors influencing long-term survival in patients with small bowel adenocarcinoma include emergency presentation, site of involvement, presence of multiple lesions and size of the tumour [10]. Systemic chemotherapy is of benefit as an adjuvant to surgery, especially when there is metastatic disease. Systemic chemotherapy for patients with advanced disease appears to provide a survival benefit with the median survival in the range of 14–20 months. Capecitabine or infusional fluorouracil combined with oxaliplatin appears to be among the most active combinations [11].

Improved outcomes with modern chemotherapy combinations and surgical options underline the importance of accurate radiological disease staging and residual/recurrent disease detection to optimise patient treatment and management. PET/CT is useful in the initial diagnosis, disease staging, evaluating response to treatment and restaging of small bowel adenocarcinoma. The primary CT and PET/CT imaging features of small bowel adenocarcinoma are that of mural thickening with increased FDG uptake (Figures 1–3) [12–14]. PET/CT allows primary lesion detection and it has been used successfully in the imaging of small bowel tumours, with one study reporting excellent sensitivity [12–14].

PET/CT permits the detection and characterisation of local and distant lymph node involvement (Figure 2). It demonstrates local tumour spread and potential invasion into local vascular structures or organs. As whole-body imaging is performed, unsuspected local and distant metastases including peritoneal and liver metastases can

Figure 1. Combined positron emission tomography (PET)/CT (upper image) and CT (lower image) demonstrating a localised adenocarcinoma of the proximal jejunum in a 59-year-old female patient (white arrow, fused PET/CT image; black arrow, CT image). No distant disease was identified and the patient underwent surgical resection. At pathology the tumour was found to extend into the peritoneum and 3/16 positive local lymph nodes were identified.

be detected that alter the stage of disease, and thus management (Figures 2 and 3). Currently, however, PET/CT's ability to detect local and distant metastatic disease has not been formally evaluated for small bowel adenocarcinoma.

With improving patient outcomes owing to systemic chemotherapy for advanced stage disease, PET may be utilised in post-treatment (chemotherapy or surgical) response assessment, restaging and/or recurrence (Figures 4 and 5).

Lymphoma accounts for 15–20% of all small bowel tumours [9]. Gastrointestinal tract lymphoma may present as primary lymphoma or as disseminated nodal disease secondarily involving the gastrointestinal tract. The most common histology is diffuse large B-cell lymphoma, with mucosa-associated lymphoid tissue lymphoma, mantle cell lymphoma, T-cell lymphoma (especially in coeliac patients) and Hodgkin's lymphoma occurring less frequently [15–17].

The best management of primary small bowel lymphoma is controversial. Owing to the absence of randomised trials in primary small bowel lymphoma,

Figure 2. 46-year-old male patient undergoing staging for duodenal adenocarcinoma. (a) Positron emission tomography/CT allows primary lesion identification with marked duodenal wall thickening (white arrow). PET/CT also demonstrates local lymph nodes, allowing their characterisation and staging [curved black arrow, peripancreatic; black arrow in (b), interaortocaval]. Furthermore it allows detection of distant lymph node metastasis [curved white arrow in (c), supraclavicular].

the optimal treatment strategy is not known. Traditionally surgical resection of the main tumour mass was the mainstay of treating small bowel lymphoma, and permitted accurate diagnosis and local staging. More recently chemotherapy and radiotherapy have been used alone, together or in combination with surgery [18]. Unanswered questions include whether the surgical approach is necessary, the extent of surgery required and whether it necessitates a delay in the use of chemotherapy. Reports by Ibrahim et al [19] and Rackner et al [20] suggest that radical tumour resectability had a highly significant effect on survival, and that surgery in combination with chemotherapy was found to be superior to other treatment combinations both in localised disease and in disseminated disease in their studies.

PET/CT is accurate for baseline staging of lymphoma and yields important prognostic information for

determining the most appropriate initial treatment (Figures 6 and 7) [21]. Used for evaluation of treatment response, PET/CT can depict residual viable malignant lymphomatous lesions with greater accuracy than can other imaging techniques (Figures 6 and 7). The findings thereby influence decisions about the need for additional or alternative treatment [21].

Although there is little literature on the specific use of PET or PET/CT in the evaluation of small bowel lymphoma as a distinct entity, the roles of PET/CT in initial staging, response assessment and disease staging of lymphoma apply. In a study by Phongkitkarun et al [22] of 33 patients with gastrointestinal tract lymphoma, 25 patients had a high-grade lymphoma and 8 had a low-grade lymphoma. In high-grade lymphoma, PET showed focal nodular or diffuse hypermetabolic activity. The average maximum SUV $\pm$ standard deviation (SD) was

Figure 3. 37-year-old male patient with adenocarcinoma of the third part of the duodenum [white arrow on PET/CT (upper) image and curved white arrow on CT (lower) image = tumour; white arrow on CT image = duodenum]. Fused positron emission tomography/CT with corresponding CT images demonstrating unsuspected liver metastases (black arrows) with resultant change in patient disease stage and management. A clear fat plane is not seen between the tumour and the superior mesenteric artery, indicating that this vessel may be involved.

11.6 ± 5.8 . After therapy, the patients whose biopsies showed no evidence of lymphoma had a lower uptake without focal lesions. The maximum $\text{SUV} \pm \text{SD}$ decreased from 11.6 ± 5.8 to 2.2 ± 0.8 . In patients whose post-treatment biopsies showed lymphoma, the maximum $\text{SUV} \pm \text{SD}$ was 9.4 ± 6.3 . Although the population means significantly differ, the size of the SD would preclude using this measure as a diagnostic parameter in individual cases. Low-grade follicular lymphomas of the colon and stomach showed diffuse hypermetabolic activity in the bowel wall (maximum SUV 8.2 and 10.3, respectively). However, the maximum SUV was 2.0–3.8 (mean 3.0) in the gastric lesions of patients with mucosa-associated lymphoid tissue (MALT) lymphoma. Similarly, in a study by Hoffmann et al [23] in patients with MALT-type lymphoma, no significant focal FDG tracer uptake was demonstrated in either gastric or extragastric lesions. Bowel activity shows some normal heterogeneity from which such a low SUV lesion might be difficult to differentiate in the absence of distinguishing CT characteristics.

Figure 4. 55-year-old male patient with residual local lymph node (black arrow) metastasis post Whipple procedure for duodenal adenocarcinoma demonstrated on axial fused positron emission tomography/CT images. Fluorodeoxyglucose (FDG) uptake at the site of surgery may be a diagnostic dilemma. When mild uptake is seen it is usually an inflammatory post-surgical finding. A linear hypodensity is seen in the liver with mild FDG uptake consistent with a retractor injury (white arrow) at the recent surgical site, and not a metastasis. The patient was subsequently treated with FOLFOX (folinic acid, fluorouracil, oxaliplatin) chemotherapy.

Response assessment

Studies have demonstrated that persistent FDG uptake after therapy may help to predict treatment failure or a high risk of recurrence [16, 22, 24–26] (Figures 6 and 7). Kumar et al [26] found the sensitivity, specificity, positive and negative predictive values of post-therapy ^{18}F -fluorodeoxyglucose (^{18}F -FDG) PET were 86%, 100%, 100% and 92%, respectively. The corresponding values for CT were 67%, 75%, 75% and 90%, respectively. Patients with positive ^{18}F -FDG PET results had statistically significantly lower disease-free survival (DFS) (0%) than did those with positive CT results (33%) ($p=0.04$; $n=19$). There was no statistically significant difference in DFS between patients with negative ^{18}F -FDG PET results and patients with negative CT results [26].

Gastrointestinal stromal tumours (GISTs) account for 10–15% of all small bowel cancers [9], most commonly present in the sixth and seventh decades, and most commonly occur in the duodenum and jejunum (80%), being less frequently seen in the ileum (20%). They typically arise in the bowel wall and may also arise in the mesentery or omentum. Metastatic disease can occur locally by direct invasion of adjacent structures or involvement of regional lymph nodes, and distant metastatic disease can involve the liver, lung, bone and peritoneum.

Only complete surgical resection has been found to be a significant favourable prognostic factor. Thus, surgical resection is the mainstay of therapy and should include any involved adjacent organs. Complete resection results in 3- and 5-year survival rates of 54% and 42%, respectively, compared with 13% and 9% after incomplete resection. Poor prognostic factors include tumours

Figure 5. 59-year-old female (same patient as in Figure 1) who underwent jejunal resection for an adenocarcinoma with positive lymph nodes at pathology. This patient underwent FOLFIRI (folinic acid, fluorouracil, irinotecan) chemotherapy regime with Avastin. Restaging fused positron emission tomography/CT and corresponding CT images at 1 year demonstrates disease recurrence with a mesenteric lymph node metastasis [white arrows in (a)] and a small bowel metastasis [black arrows in (b)].

greater than 5 cm in diameter, non-smooth muscle cell differentiation and histological classification as high grade.

Chemotherapy

Approximately 85% of GISTs have oncogenic mutations in KIT (Kit receptor tyrosine kinase) and about 5–7% of GISTs have activating mutations of the homologous

platelet-derived growth factor receptor alpha (PDGFRA) kinase. The remaining GISTs do not possess a KIT or PDGFRA mutation and are commonly termed “wild-type” GISTs. The tyrosine kinase inhibitors imatinib and sunitinib have shown good response rates. Imatinib mesylate is a very effective agent for the treatment of metastatic or surgically unresectable GIST, given its ability to selectively inhibit KIT and PDGFRA. Although the majority of GIST patients achieve clinical benefit when treated with imatinib, approximately 10% will progress

Figure 6. 60-year-old male patient with small bowel lymphoma [white arrows in (a)] and images from fused positron emission tomography (PET)/CT and CT images demonstrating a concentrically thickened small bowel segment that is aneurysmally dilated. Separate “skip lesions” of small bowel lymphomatous disease are seen. Extensive bulky mesenteric adenopathy is demonstrated. Biopsy yielded diffuse large B-cell lymphoma. PET/CT not only demonstrates the extent of local disease but also demonstrates a right axillary lymph node [white arrow in (b)] with significant activity. Response assessment: significant reduction in disease and fluorodeoxyglucose (FDG) uptake after 6 weeks of chemotherapy [black arrows in (a) and (c)].

Figure 7. 39-year-old male patient with small bowel T-cell lymphoma. Small bowel lymphoma is demonstrated on positron emission tomography (PET)/CT with a concentrically thickened small bowel segment, which is aneurysmally dilated, the depiction aided by positive intraluminal contrast, which is fludeoxyglucose (FDG)-avid on the fused PET/CT image [black arrows in (a)]. (a) Mesenteric infiltration and mesenteric adenopathy [white arrows on pre-coronal images in image series (b)] are also seen, which is characteristic of small bowel lymphoma. (b) Response assessment: this case demonstrates mixed response to CHOP (cyclophosphamide, adriamycin, vincristine, prednisone) chemotherapy of the small bowel tumour element, which is less FDG-avid, with enlarging diffuse and confluent mesenteric disease/lymphadenopathy (black curved arrow). Interval development of splenomegaly (black straight arrow) (with FDG uptake equal to or greater than the liver) is indicative of lymphomatous involvement.

within 3–6 months of initiating therapy. Such cases are regarded as showing primary resistance to treatment. An additional 40–50% of patients will go on to develop imatinib resistance within 2 years, after enjoying a partial response or at least disease stabilisation during initial follow-up. These patients are classified as having delayed resistance [27].

Demetri et al [28] performed a placebo-controlled trial for imatinib-resistant or -intolerant patients. A highly significant improvement in progression-free survival (PFS) was seen; patients treated with sunitinib had a median PFS of 24.1 weeks compared with 6 weeks for those on placebo. Partial response was seen in 7% of sunitinib patients with 58% achieving stable disease, whereas there were no responses in the placebo group. These data led to approval of sunitinib as second-line therapy for GIST.

Disease detection

All published reports have documented that FDG-PET/CT is superior to CT and a better guide in predicting early response to imatinib therapy (Figures 8 and 9). Antoch et al [29] found in a comparative study of PET, CT, PET/CT for monitoring response to treatment that PET/CT detected more metastases from GISTs than CT or PET alone. In this study PET/CT detected 282

lesions, whereas 249 were detected on CT alone and 135 by PET alone ($n=20$ patients with GIST) [29]. Because ^{18}F -FDG-PET imaging is a functional imaging study that can evaluate tumour metabolism over time, a baseline scan is recommended prior to initiating treatment. Conducting a baseline evaluation allows one to establish a denominator against which qualitative or quantitative measurements, such as the SUV or maximum SUV, can be compared on follow-up studies [30].

Disease response assessment

In characterising response to imatinib, a similar improved accuracy was demonstrated with PET/CT. Tumour response was correctly characterised in 95% of patients after 1 month and 100% after 3 and 6 months with PET/CT. PET and CT images viewed side by side were correct in 90% of patients at 1 month and 100% at 3 and 6 months. PET accurately diagnosed tumour response in 85% of patients at 1 month and 100% at 3 and 6 months. CT was found to be accurate in 44% of patients at 1 month, 60% at 3 months and 57% at 6 months. Hounsfield units were found to decrease by at least 25% in 12 of 14 responders after 1 month [29].

There is evidence that serial PET study is more sensitive and reliable for determining treatment response to imatinib mesylate than CT and that reduction in FDG

Figure 8. 46-year-old male patient with a partially exophytic duodenal gastrointestinal stromal tumour that is intensely fludeoxyglucose-avid (black arrows).

uptake is predictive of disease-free survival. Holdsworth et al [31] assessed potential early prognostic PET and CT indicators of response to imatinib mesylate in GIST. They found that the two best discriminators were PET maximum SUV and CT bidimensional measurement of no growth from baseline to 1 month in patients with advanced GIST.

From a quantitative standpoint, the reduction in uptake correlated closely with patient outcome as reported by Stroobants et al [32]. Progression-free survival at 1 year was 92% in PET responders ($n=13$; response defined as a decrease in ^{18}F -FDG uptake of more than 25%), whereas the same was only 12% for patients who were classified as non-responders by PET ($n=8$; $p<0.005$).

Secondary point mutations in GIST tumours result in acquired resistance to imatinib [33, 34]. Detection of disease recurrence or rapid progression on discontinuing imatinib and acquired resistance to imatinib with disease flare phenomenon on imatinib termination [30] should help to provide insight into the issue of therapeutic endpoint definition. Similar to other tumours, FDG-PET may prove valuable for early detection and study of imatinib resistance and thereby help in adopting alternative approaches early in imatinib-refractory disease [30]. Furthermore, PET/CT is helpful in guiding biopsy by targeting those areas of most intense FDG uptake that are most likely to harbour cellular/metabolically active malignant tissue, thus reducing sampling errors.

Pitfalls in imaging include cystic tumours that have increased in size being erroneously diagnosed as disease progression at CT [35].

Carcinoid tumours account for approximately 30% of all small bowel tumours [9]. Patients with carcinoid most commonly present in the seventh decade and the site of disease increases in frequency from the duodenum to the ileum. Surgical excision is the mainstay of therapy and isolated disease is widely resected. Should a solitary and/or obstructing metastasis occur, surgical resection is performed; however, if lesions are multiple, chemotherapy is utilised.

Imaging features of carcinoid tumours include tumour invasion into the mesentery, which leads to fibrosis and often kinking of the small intestine. Coupled with

Figure 9. (a) 47-year-old female patient with a small bowel gastrointestinal stromal tumour at presentation (black arrow). (b) Follow-up imaging shows some reduction in fludeoxyglucose (FDG) uptake; however, disease progression is seen medially (white arrow), and increased FDG uptake is also seen in ascites adjacent to the liver consistent with malignant ascites (white curved arrow). (c) Further follow-up imaging demonstrates cystic tumour change, which, although without FDG uptake, has increased in size, and so may be erroneously simulating tumour progression (black curved arrow). There is a reduction in the FDG avidity of the ascites, also consistent with response to treatment.

Figure 10. 56-year-old male patient with carcinoid involving the small bowel. An irregular mass with focal calcifications within it is seen (black arrow), without significant fludeoxyglucose uptake within it, as seen on the corresponding positron emission tomography image.

thickening of the vessel wall, this may lead to ischaemic changes in the gut and commonly present with obstruction. Serotonin is postulated to be responsible for these features. Carcinoid tumours are typically FDG negative at PET/CT, although newer agents such as ^{18}F -dihydroxyphenylalanine PET are showing promising results (Figure 10) [36, 37].

Small bowel metastasis

Secondary neoplastic involvement of the small intestine is as frequent as primary small bowel neoplasia. Primary tumours of the colon, ovary, uterus and stomach can typically involve the small bowel by direct invasion or intraperitoneal spread. Primary tumours from breast, lung and melanoma metastasise to small bowel haematogenously [38].

Tumour metastasis to the small bowel results in advanced stage disease with a poor prognosis, except in the case of a potentially resectable solitary metastasis. Treatment is generally palliative, with appropriate disease-specific chemotherapy, and resection or intestinal bypass for cases of intestinal obstruction or haemorrhage.

Figure 11. 63-year-old male patient with metastatic colorectal cancer to the small bowel (white arrow) and liver (black arrow) post-transverse colectomy for metastatic colon cancer. He was treated with FOLFOX [folinic acid, fluorouracil, oxaliplatin] chemotherapy.

In general, small bowel metastases demonstrate increased FDG uptake at PET imaging similar to their primary tumour (Figures 11–13) [38].

Metastatic melanoma may disseminate to the small bowel, small bowel mesentery and draining lymph nodes [39, 40]. Although PET has a limited role in the assessment of T and N status of patients with melanoma, it has been shown to have an important role in assessing metastatic disease beyond local regional lymph nodes. The excellent capabilities of FDG PET in detecting recurrent metastatic malignant melanoma are well established. A meta-analysis by Schwimmer et al [41] of 13 studies assessing FDG PET in patients with malignant melanoma revealed an overall sensitivity of 92% and specificity of 90% for recurrent melanoma throughout the body (Figure 13).

Non-neoplastic causes of fluorodeoxyglucose uptake and imaging pitfalls

Pitfalls of small bowel PET/CT imaging primarily result from non-malignant causes of increased FDG PET uptake. These include normal physiological uptake (Figure 14a), uptake associated with inflammatory conditions such as Crohn's disease (Figure 14b), and infectious, antibiotic-induced or radiation enteritis and graft-versus-host disease (Figure 14c). In general tumours present as shorter-segment, more focal-intense lesions, while non-malignant lesions are longer in length; however, considerable overlap exists.

Other pitfalls include non-FDG avid tumours (discussed above), including MALT lymphoma and carcinoid tumours, and cystic tumour change following

Figure 12. (a) 50-year-old female patient with poorly differentiated adenocarcinoma of the endometrium (black arrows) metastatic to the small bowel (white arrows) demonstrated on (a, b) axial fused positron emission tomography/CT and corresponding CT images.

treatment erroneously simulating tumour increase in size (Figure 9).

¹⁸F-fludeoxyglucose positron emission tomography in Crohn's disease

Crohn's disease is a chronic inflammatory disease of the gastrointestinal tract, which is characterised by multiple episodes of remissions and relapses. CT and magnetic resonance enterography are fast emerging as imaging investigations of choice for evaluation of Crohn's disease [42, 43]. In patients with Crohn's disease

Figure 13. 32-year-old male patient with metastatic melanoma. (a) Axial fused positron emission tomography (PET)/CT and coronal fused PET/CT demonstrate a small bowel intussusception with a melanoma metastasis at the lead point was found unexpectedly at PET/CT (white arrow).

where therapeutic decisions depend on the objective assessment of extent and severity of lesion and disease activity, ¹⁸F-FDG PET, being a functional imaging tool, may be a valuable adjunct [44, 45]. ¹⁸F-FDG PET/CT in Crohn's disease in general shows good correlation with the clinical, endoscopic and biological activity of the disease [44–46]. Das et al [42] also demonstrated that PET/CT enteroclysis enabled detection of significantly more lesions, and is a feasible and promising technique. PET/CT also enables monitoring of response to treatment by documenting the disease activity before and after treatment [47]. Spier and colleagues [48] have demonstrated that FDG activity decreases with successful treatment of inflammation in active inflammatory bowel disease, and this decrease in FDG activity correlates with symptomatic improvement.

Conclusion

FDG PET/CT can play an important role in the assessment of patients with small bowel tumours. Recognition of the imaging appearances of such small bowel tumours, knowledge of their patterns of disease spread and awareness of potential interpretation pitfalls are all important for optimal PET/CT interpretation and for resulting maximal patient benefit.

Figure 14. (a) Normal uptake within the small bowel and intense uptake in the right ureter due to excretion of fludeoxyglucose (FDG) (white arrow). (b) 32-year-old male patient undergoing restaging positron emission tomography (PET)/CT for lymphoma. He also had a history of active Crohn's disease, identified on PET/CT as mucosal enhancement, which is easily seen in contrast to the neutral intraluminal contrast (white arrow). (c) 56-year-old male patient with a prior history of acute myeloid leukaemia status post-allogeneic stem cell transplant with multifocal gastrointestinal graft-versus-host disease diagnosed at status post-ileal bowel resection. PET/CT demonstrates two separate areas of ileal involvement (white arrow, terminal ileal; black arrow, ileal involvement).

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