^{18}F-fluorodeoxyglucose Positron Emission Tomography/Computed Tomography in Postsurgical and Postprocedural Setting in Thorax and Abdominopelvic Malignancies: A Pictorial Essay (Part II)

Abstract

This pictorial essay depicts normal appearances, complications and residual or recurrent disease on fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET/CT) studies in the postsurgical and postprocedural setting, other than head and neck malignancy. Reading and reporting FDG PET/CT in this scenario is daunting due to the multiple confounding false positives seen during this period. This article which is the second part in this series will familiarize the readers with the normal appearance and pitfalls seen in FDG PET/CT studies in thoracic and abdominopelvic malignancies during the postoperative and postprocedural period so as to avoid misinterpretations.

Keywords: *Contrast-enhanced, false-positives, fluorodeoxyglucose positron emission tomography/computed tomography, pitfalls, postoperative, postsurgical, recurrence*

Archi Agrawal, Anjali Prakash, Sayak Choudhury, Manikandan MV, Yash Jain, Nilendu Purandare, Ameya Puranik, Sneha Shah, Venkatesh Rangarajan

Department of Nuclear Medicine and Molecular Imaging, Tata Memorial Hospital, HBNI (Homi Bhabha National Institute), Parel, Mumbai, India

Address for correspondence:
Dr. Archi Agrawal, Department of Nuclear Medicine and Molecular Imaging, Tata Memorial Hospital, E. Borges Road. Parel, Mumbai - 400 012, Maharashtra, India.
E-mail: drarchi23@gmail.com

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Introduction

In the past few decades, fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET CT) has established itself as a very effective imaging modality in staging and restaging of various cancers. Reporting FDG PET/CT in the postsurgical period can be a challenge due the postoperative changes which lead to alteration in normal anatomy and inflammation/infections that occur during this period. FDG accumulates in healing wounds due to the presence of granulation tissue and macrophages.[1] Understanding the changes that take place during this setting will help to avoid misinterpretation and correct reporting. The first part of this article dealt with case scenarios in the postsurgical setting in head and neck malignancies. In this second part, we shall contemplate on the pitfalls in thoracic and abdominopelvic malignancies in the portsurgical and postprocedural period.

Learning objectives

1. Familiarly with normal postsurgical and postprocedural appearances in thorax, abdomen, and pelvis
2. Familiarity with physiological findings and normal variants which are potential mimics for disease involvement
3. Methods to differentiate between recurrent disease and postsurgical/postprocedural appearances and complications
4. Importance of doing intravenous contrast-enhanced CT (ceCT) with PET/CT.

Case Scenarios

Thorax

Extensive surgical procedures are performed for curative treatment of local and locoregional esophageal and lung malignancies. It is important to familiarize oneself with the various transthoracic esophagectomy (TTE) surgeries and the various complications that may occur after these surgeries. One of the most common TTE procedures is the Ivor Lewis procedure, in which the diseased esophagus is dissected out and the stomach is used to create a gastric tube or conduit in place of the esophagus.[2] FDG PET/CT usually shows a photon-deficient area in the right paravertebral region corresponding to the gastric pull-up surgery [Figure 1]. Sometimes, diffuse uptake may be seen around the gastric pull-up due to inflammation postsurgery [Figure 2]. Diffuse nature of uptake with no soft-tissue

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mass points towards an inflammatory nature. Occasionally, an endoscopy done to diagnose an esophageal carcinoma may cause a perforation in the esophageal wall. It is a very rare complication. It shows diffuse FDG uptake due to inflammation and sometimes due to co-existing infection [Figure 3]. The presence of extraluminal air is the characteristic finding in perforations. This is a life-threatening complication, but small perforations may be managed conservatively.[3] In locally advanced inoperable esophageal cancers, who receive chemoradiotherapy, an esophageal stent is placed to relieve the patient of dysphagia and to improve the quality of life.[4] Recurrence is seen as FDG avid, enhancing soft-tissue mass along the stent [Figure 4].

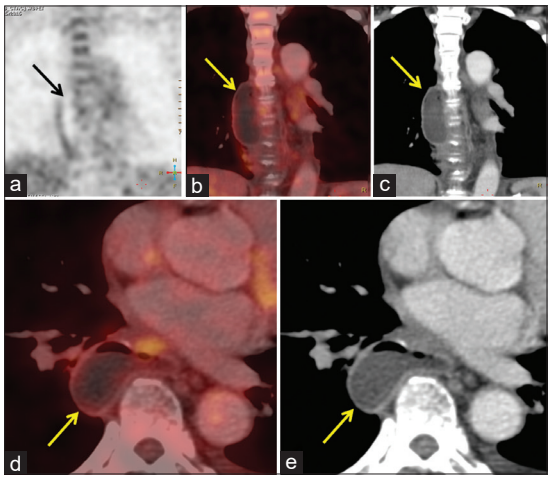

Figure 1: (a) Normal appearance posttransthoracic esophagectomy. 62-year-old male, a case of carcinoma of the lower esophagus, posttotal esophagectomy. The fluorodeoxyglucose PET/CT scan shows a photon-deficient area in the right paravertebral region, corresponding to the gastric pull-up surgery in the coronal PET, coronal fused PET/CT and the axial fused PET/CT and CT images (arrow in a-e). PET/CT: Positron emission tomography/computed tomography

In patients of lung carcinoma, intractable pleural effusions are usually treated with pleurodesis. The process of pleurodesis involves installation a chemical irritant like talc, which produces inflammation and pleural fibrosis. This is characterized by proliferation of fibroblasts and macrophages, which leads to increased FDG uptake. This may last for more than 10 years.[5] FDG PET/CT shows diffuse or focal areas of intense FDG uptake with corresponding hyper-attenuating areas on CT that are diagnostic of pleurodesis [Figure 5]. These should not be mistaken for pleural deposits, which though FDG avid have a soft-tissue attenuation. The past history of pleurodesis is usually helpful. FDG uptake can also be seen Post-mediastinoscopy at the site of incision in the suprasteranl region, at sites of intercostal drainage for pleural effusion and at scar sites postsurgery, due to inflammation.[1] These show diffuse

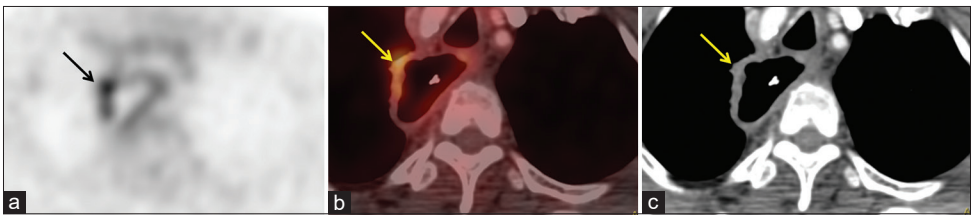

Figure 2: Postoperative changes, post-TTE. 64-year-old man, postesophagectomy for carcinoma of esophagus. PET/contrast-enhanced CT was done 6 weeks after the surgery. Axial PET, fused PET/CT and CT images show diffuse fluorodeoxyglucose uptake around the gastric pull-up, in the right paravertebral region (arrow in a, b, c). This is due to postoperative inflammation which gradually subsides in a few days. PET/CT: Positron emission tomography/computed tomography

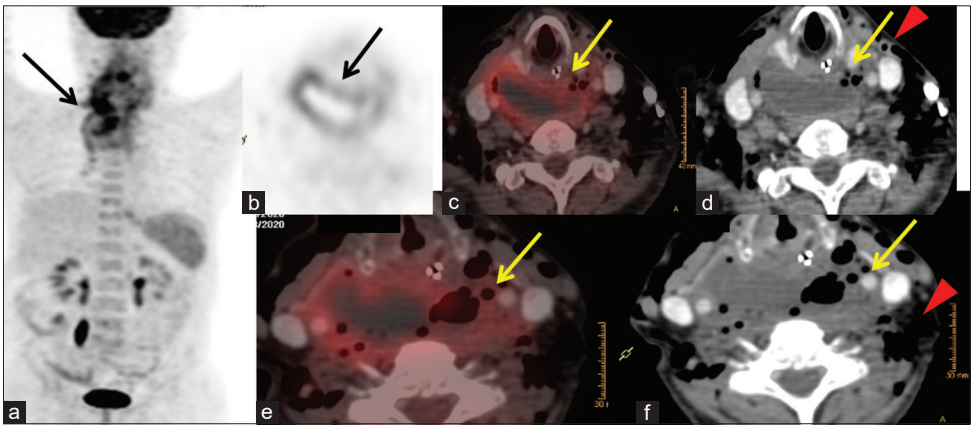

Figure 3: Esophageal perforation postendoscopy. 62-year-old man was being evaluated for an upper esophageal lesion. FDG PET/contrast-enhanced CT was done 7 days after an endoscopy. FDG PET/CT shows diffuse FDG uptake in the lower neck and upper mediastinum in the maximum intensity projection image (arrow in a). The axial PET, fused PET/CT and CT images show a central necrotic component with multiple air-pockets with a rim of increased FDG uptake in the region of the pharynx and upper esophagus (arrows in b-f). Also note the subcutaneous emphysema (arrowhead in d, f). FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

FDG uptake and can easily be diagnosed as reactive postprocedural changes.

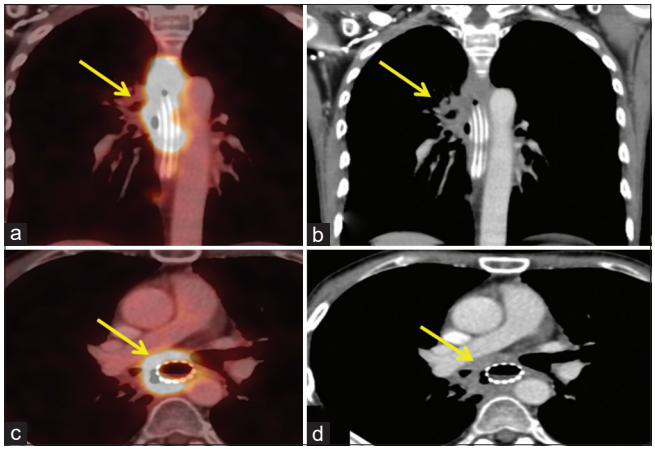

Figure 4: Esophageal stent with recurrence. 59-year-old male, carcinoma esophagus, treated with chemotherapy and radiotherapy with placement of an esophageal stent. Fluorodeoxyglucose PET/CT was done 2 years after treatment. The coronal and axial fused PET/CT show fluorodeoxyglucose avid recurrent soft-tissue around the esophageal stent (arrow in a, b, c, d). PET/CT: Positron emission tomography/computed tomography

Healing after breast surgery also involves inflammatory reaction with accumulation of leukocytes and macrophages, with a consequence of FDG uptake in the postoperative area. Fat necrosis is a common condition seen after breast surgeries and trauma. It is a benign inflammatory condition and may mimic breast malignancy.[6] This is seen on FDG PET/CT as FDG avid hypodense lesion [Figure 6]. History of previous surgery and hypodense, non-enhancing appearance on CT is giveaway to a benign lesion. Breast seroma is another such condition seen postsurgery or post trauma. This is a collection of serous fluid which gets reabsorbed in a few weeks to months. This appears on FDG PET/CT as a hypodense collection with no FDG uptake [Figure 7].[7] A recent history of surgery is usually diagnostic. These resolve on its own and no intervention is generally needed. In spite of few false positives, FDG PET/CT is a powerful tool for the detection of recurrence in the chest wall [Figure 8], axilla and extra-axillary nodes with a high sensitivity and specificity of >90%.[8]

Abdomen and pelvis

In cancers of the hepatobiliary tract, percutaneous transhepatic biliary drainage is often done to relieve the

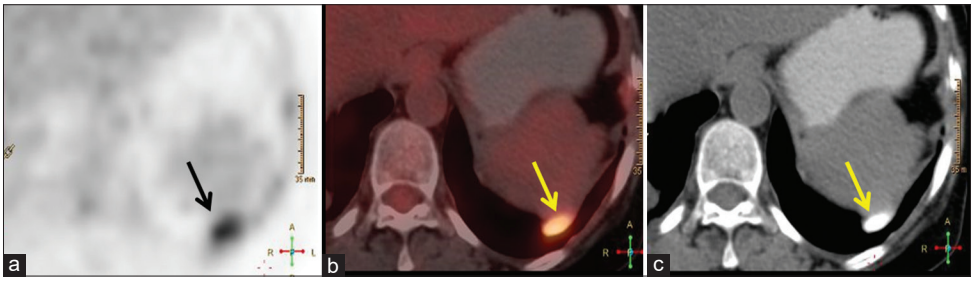

Figure 5: Pleurodesis. The axial PET and fused PET images show fluorodeoxyglucose avid focal area in the left pleura (arrow in a, b). On the axial CT image, there is focal hyper-attenuationg area in the corresponding region in the left pleura (arrow in c). This is due to inflammatory reaction after talc pleurodesis. PET/CT: Positron emission tomography/computed tomography

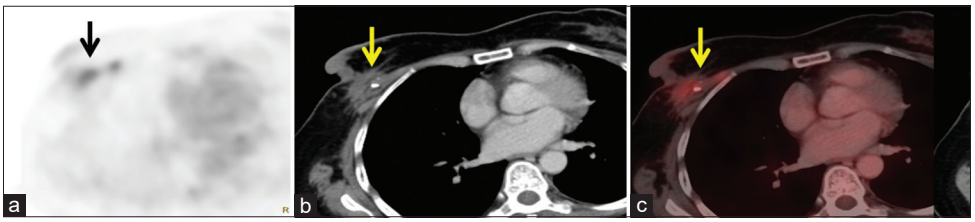

Figure 6: Fat necrosis-FDG PET/CT in a 40-year-old lady who had undergone right breast surgery for carcinoma breast. Low grade FDG uptake (arrow in a, c) is noted in the hypodense, non-enhancing lesion (arrow in b) in right chest wall at the site of previous surgery. This is due to benign fat necrosis, seen postsurgery and often after trauma. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

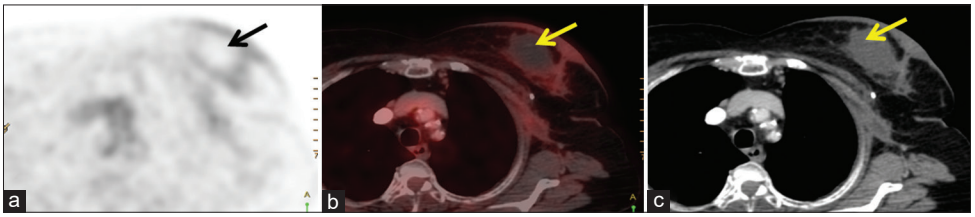

Figure 7: Seroma. FDG PET/CT in a 38-year-old female with left breast carcinoma, 8 weeks' postsurgery. Hypodense collection is noted in the region of the left breast with no FDG uptake (arrow in a, b, c). This appearance is typical of a seroma and this subsides with time, in a few weeks to months. Also note the surrounding FDG avid postoperative inflammatory changes. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

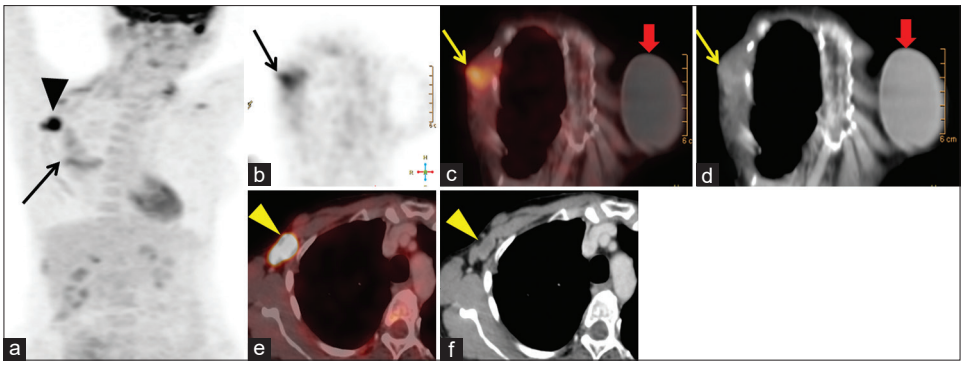

Figure 8: Chest wall recurrence. 36-year-old female treated for bilateral breast carcinoma. FDG PET/CT was done 1 year after surgery. Maximum intensity projection image of FDG PET/CT scan, shows an area of diffuse, linear FDG uptake (arrow in a). The fused coronal PET/CT images show hypermetabolic, enhancing area in the right chest wall, corresponding to recurrent disease (arrow in b, c, d). This was proven histopathologically. Also seen is the left breast prosthesis (block arrow in c, d). The arrow heads in a, e, f show hypermetabolic metastatic right axillary node. Though maximum intensity projection shows diffuse and linear uptake, seeing the images in all the reconstruction planes, namely transaxial, sagittal and coronal planes will lead to correct identification of the lesion. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

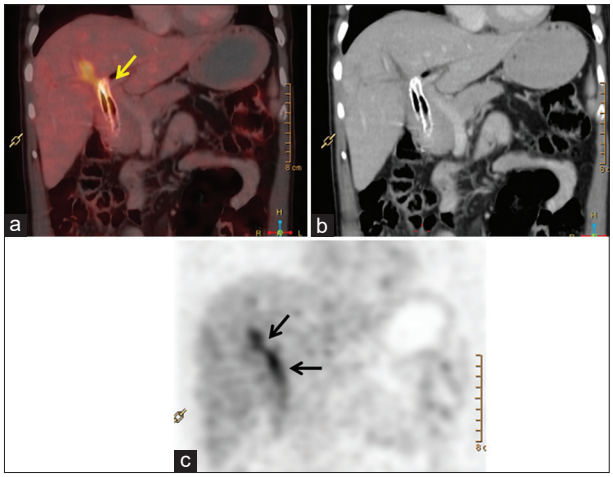

Figure 9: Inflammation around the biliary stent. 64-year-old male, a case of hilar cholangiocarcinoma. The patient was referred for a PET/CT 4 weeks after percutaneous transhepatic biliary drainage and bilateral self-expanding metallic stent placement. Coronal fused PET/CT and PET images show linear FDG uptake along the biliary stent (arrow in a, b, c). This is due to inflammatory changes. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

obstruction along the biliary tract with the placement of metallic stent. Often FDG PET/CT is done for staging of the disease after placement of the stent. Local inflammation occurs which is seen as linear increased FDG uptake along the stent [Figure 9]. This uptake is linear and diffuse and can be easily identified as benign FDG uptake.[9] Cholangitic abscess is another common complication Post-stent placement. These may appear as focal areas with increased metabolic activity and is a potential mimic for metastatic disease. Dilated biliary radicals with increased FDG uptake along the walls of the biliary ducts is typically seen in cholangitis/cholangitic abscess [Figure 10].[10] Tracking these lesions by moving the cursor up and down on the CT image, will show the relationship of these lesions to the dilated biliary radical, helping us to differentiate between metastatic lesions which are focal whereas cholangitic abscess are associated with the dilated biliary radicals.

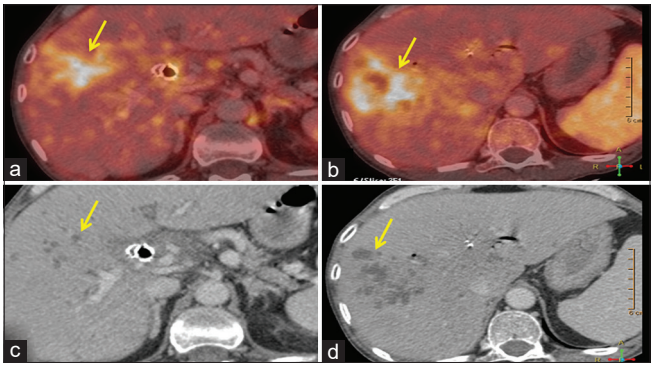

Figure 10: Cholangitic abscesses poststenting. 63-year-old male a case of cholangiocarcinoma. FDG PET/CT was done 10 weeks' poststent placement. Axial fused PET/CT and CT images show increased FDG uptake in the right lobe of liver, along the biliary radicals (arrows in a, b, c, d). Note the dilated biliary radicals in CT image (arrow in c, d). FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

Abdominal surgeries done for colorectal cancers, may compromise blood flow to the omentum, resulting in omental infarction or fat necrosis. This is an inflammatory, self-limiting process. The appearance of omental infarction of an FDG avid lesion is a mimic for intra-peritoneal metastatic deposit. The presence of fat within this lesion with an enhancing rim helps us to correctly identify this lesion as benign fat necrosis [Figure 11]. Another name for this is epiploic appendagitis.[7,11] In colonic surgeries, inflammation at the anastomotic site may mimic recurrent disease, because this presents as mass like lesion with increased FDG uptake [Figure 12]. Surrounding fat-stranding may be more profound in an inflammatory condition. The lesion and the uptake gradually decrease with time.[12]

Inflammation and fat stranding is also common after renal surgeries and nephrectomies. The inflammatory fat stranding may be mass like in morphology. FDG PET/CT done too early after the surgery and fat stranding at the operated site should make us suspect an inflammatory etiology. The inflammation and fat stranding generally

decrease with time and a follow-up imaging is extremely helpful to precisely differentiate this from recurrent/residual disease. It may be very subtle as shown in Figure 13 and very pronounced as shown in Figure 14.

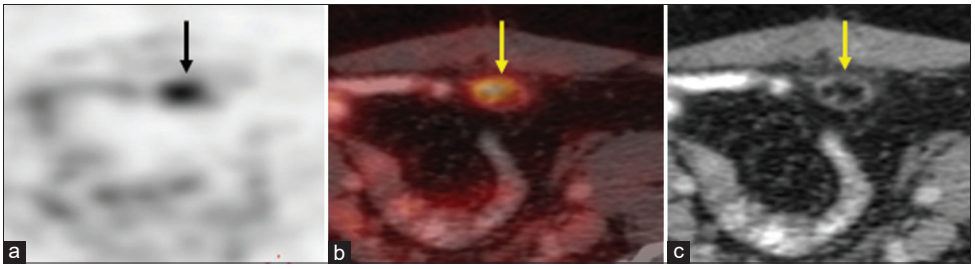

Figure 11: Omental infarction or epiploic appendagitis. 45-year-old male had undergone Anterior Resection surgery for carcinoma of the rectum. FDG PET/CT was done 6 months after the surgery. Axial PET and fused PET/CT images show an area of increased FDG uptake in the anterior abdomen, just posterior to the anterior abdominal wall (arrows in a, b). In the axial CT image this lesion shows fat within it, with an hyperattenuating rim (arrow in c). This is a classical finding seen in omental infarction/benign fat necrosis. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

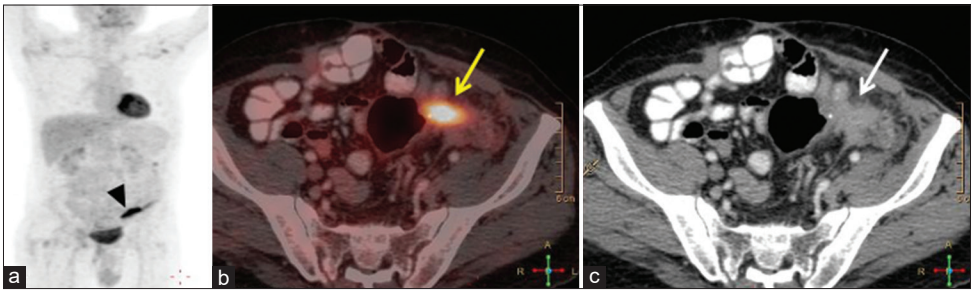

Figure 12: Inflammation at anastomotic site. 60-year-old male a case of sigmoid colon, postsigmoid colectomy. FDG PET/CT was done 14 months after surgery. FDG PET/CT, maximum intensity projection image shows a linear area of increased FDG uptake in the left lower abdomen (arrowhead in a). Axial fused PET/CT images show a hypermetabolic mass at the anastomotic site (arrow in b, c). This was suspicious for recurrent mass lesion and thus a biopsy was done. The biopsy revealed acute and chronic inflammation with granulation tissue and giant cells. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

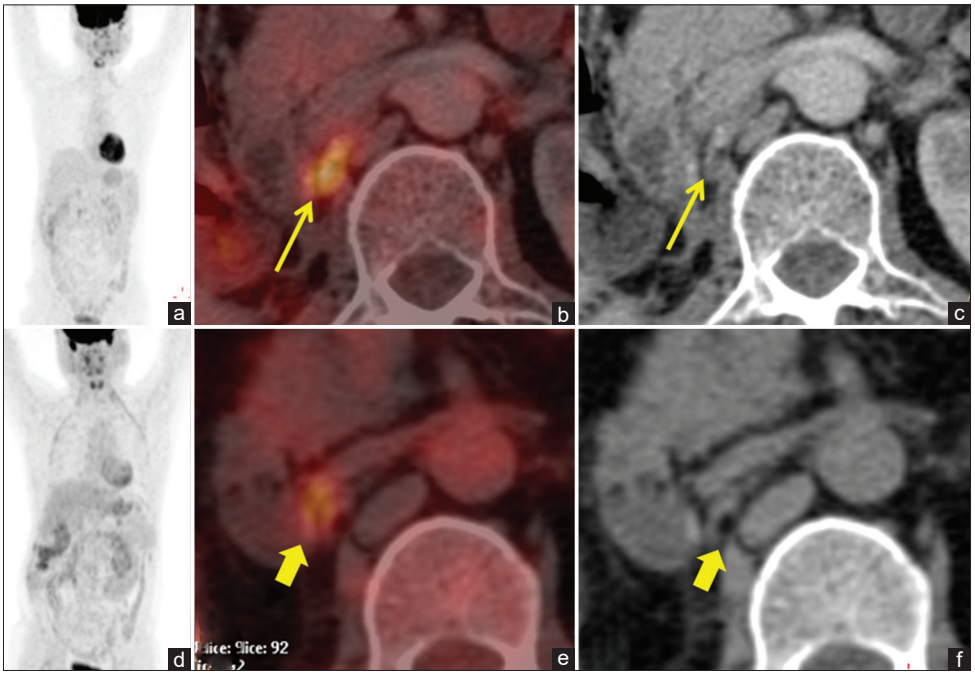

Figure 13: (a) Postoperative inflammation in renal fossa. 52-year-old male, a case of renal cell carcinoma of right kidney. Underwent right radical nephrectomy 6 weeks prior to the FDG PET/CT study. The PET/CT study shows FDG avid area in the right retrocaval region, with fat stranding at the postnephrectomy site in the axial fused PET/CT and CT images (arrow in b, c). This area corresponds to postoperative inflammation. Note the absence of any mass lesion in this area. A follow-up PET/CT done 10 months later shows decrease in FDG uptake and soft-tissue stranding (block arrows in e, f in the axial fused PET/CT and CT images). The decrease in FDG uptake in the follow-up imaging without any treatment confirms these findings to be benign. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

A very rare and serious surgical complication is a retained surgical sponge or a mop in the abdominal cavity. This leads to inflammation and foreign body reaction leading to formation of a granuloma, which may mimic a soft tissue neoplasm. Due to intense inflammatory reaction, FDG uptake is seen in a retained mop, also known as gossypiboma [Figure 15]. Air trapping within the surgical mop is a characteristic finding seen on CT and is diagnostic [13,14] of this potential pitfall.

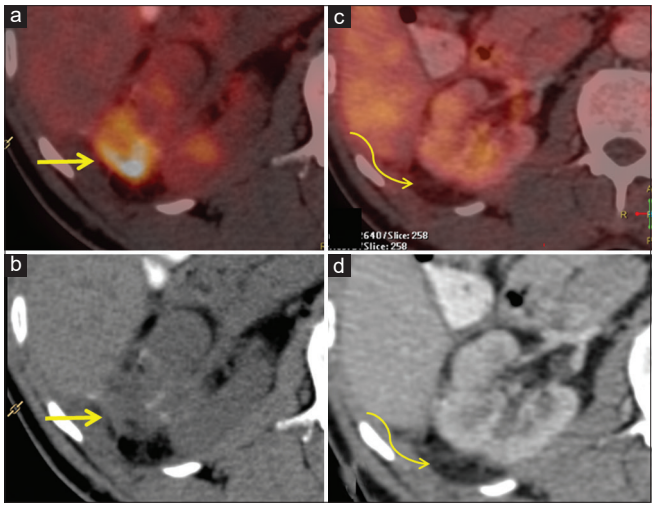

Figure 14: Postoperative inflammation in renal fossa. 46-year-old male, a case of clear cell carcinoma of right kidney, postpartial nephrectomy. FDG PET/CT done 8 weeks after the surgery, shows FDG avid area in the lateral aspect of the right kidney, at the operated site in the axial fused PET/CT image (arrow in a). Note the fat standing with suture granulomas in the CT image (arrow in b). A biopsy revealed chronically inflamed fibrocollagenous tissue with histiocytes, gaint cells and hemosiderin macrophages. A follow-up PET/CT done 2 months later shows complete disappearance of the FDG avid inflammatory lesion (curved arrow in c, d) in the axial fused PET/CT and CT images. Note the subtle fat stranding in c, d. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

Response assessment after radiofrequency ablation (RFA) of metastatic liver and lung is commonly done with FDG PET CT. Diagnosing completeness of ablation and residual disease is usually straight forward on FDG PET/CT when the response assessment is done 24–48 h post-RFA. After this period, inflammatory changes start to set in along the periphery of the lesion. These changes usually show low grade, uniform, and diffuse FDG uptake. At times, when the post-RFA assessment scan is done too late after the ablation, it might be difficult to differentiate between residual disease and inflammation.[15]

Another potential pitfall in the pelvis is seen in patients with urinary diversion surgery and postradical cystectomy with ileal conduit due to physiologic excreted tracer. This may mask disease in the lower abdomen and pelvis. Vesicovaginal fistula is a false positive, seen postsurgery and radiotherapy in patients with cervical cancer. Delayed imaging is usually helpful in such cases.[16]

Scar site implants are commonly seen Post-laparoscopic surgeries along the track and also sometimes Post-open

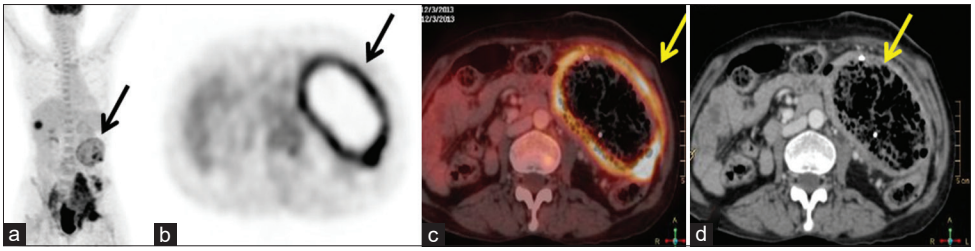

Figure 15: Retained surgical mop. 53-year-old female, was operated elsewhere for anorectal melanoma (postabdomino-perineal resection) 3 months back, presented to our institute with an abdominal mass and anal fistula. FDG PET/CT showed a well circumscribed area in the left side of the abdominal cavity with FDG uptake in its rim with a central area of no FDG uptake (arrow in a), axial PET showing the same (arrow in b). The axial fused PET/CT shows multiple air-pockets within this area (arrow in d) with hypermetabolic rim (arrow in c). There was no communication with the bowel loops. The peripheral hypermetabolic rim is due to inflammatory response. These features are classically seen in a retained mop/sponge, also known as gossypiboma. Apart from this, extensive disease was noted in the pelvis and abdomen. FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

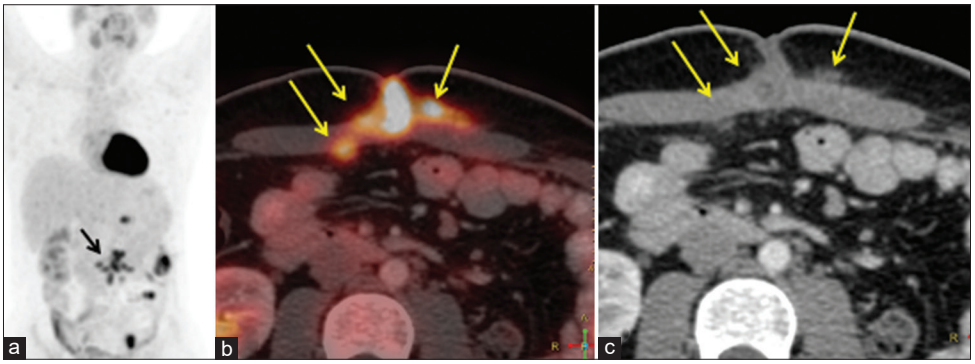

Figure 16: (a) Scar site implants. 43-year-old male, a case of renal cell carcinoma of the left kidney postleft nephrectomy. FDG PET/CT done 2 months after the surgery. Maximum intensity projection, axial fused PET/CT and CT images show FDG avid lesions at the scar site in the subcutaneous tissue and anterior abdominal wall (arrow in a, b, c). FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

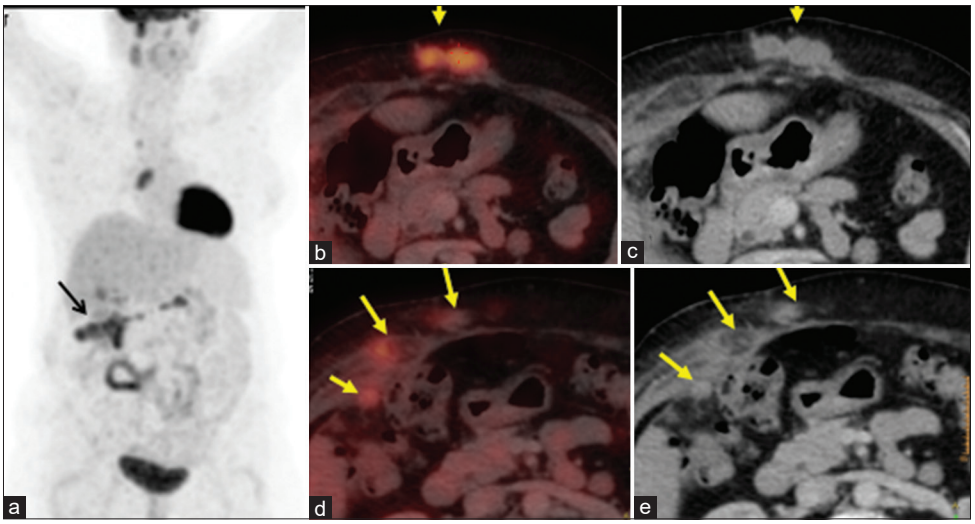

Figure 17: Scar site implants. 45-year-old female, postopen cholecystectomy for gall bladder carcinoma. FDG PET/CT was done 3 months' postsurgery. FDG PET/CT scan. Maximum intensity projection, axial fused PET/CT and CT images show multiple FDG avid lesions along the scar in the subcutaneous tissue and anterior abdominal wall (arrow in a, b, c, d, e). FDG: Fluorodeoxyglucose, PET/CT: Positron emission tomography/computed tomography

abdominal surgeries. These are usually mass like enhancing lesions with FDG uptake [Figures 16 and 17].[17] These should not be mistaken with postoperative inflammation at the scar-site. Postoperative inflammatory changes are usually diffuse with low-grade FDG uptake with fat-stranding. There is the absence of mass-like enhancing lesions in the postoperative changes. PET/CT is the imaging modality of choice for the detection of scar site recurrence.

Conclusion

These are few mimics seen during postoperative period and after invasive procedures. It is necessary to get acquainted with potential false positive mimics due to inflammation, infections, and complications during this period, for confident reporting of FDG PET/CT studies. Proper knowledge of the procedure, correct timing for performing the scan, performing a diagnostic CT with intravenous and oral contrast and awareness of the PET/CT appearances will help in prompt and precise diagnosis.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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