# Artefacts and Pitfalls in PET/CT Imaging of Colorectal Cancer


Sahar Rezaei,PhD

Assistant Professor

Tabriz University of Medical Sciences

*PhD in Medical physics, Department of Medical physics and Biomedical Engineering, Tehran University Of Medical Sciences*

# Colorectal Cancer

- In the past two decades, PET/CT has become an essential modality in oncology increasingly used in the management of colorectal cancers, being used for diagnosis, staging, evaluation of treatment response, and assessment of prognosis.

# Colorectal Cancer

- In the past two decades, PET/CT has become an essential modality in oncology increasingly used in the management of colorectal cancers, being used for diagnosis, staging, evaluation of treatment response, and assessment of prognosis.

- Most PET/CT tracers used in clinical practice show some degree of colorectal uptake.

# Colorectal Cancer

- In the past two decades, PET/CT has become an essential modality in oncology increasingly used in the management of colorectal cancers, being used for diagnosis, staging, evaluation of treatment response, and assessment of prognosis.

- Most PET/CT tracers used in clinical practice show some degree of colorectal uptake.

- One must also be aware of technical artifacts causing difficulties in interpretations.

- It is imperative to know the common variants and benign diseases that can mimic malignant pathologies.

# Outline

- Technical Artifacts in imaging
- Physiological Variants
- Organ- and Pathology-Specific Pitfalls

# Outline

- Technical Artifacts in imaging
  - Errors in CT-Derived Attenuation Coefficients
    - ✓ Misalignment
    - ✓ Truncation Artefacts
    - ✓ Contrast Medium
    - ✓ Metallic Implant
  - Partial volume effect

# Misregistration

- Misregistration is an incorrect superimposition of PET and CT data on a fused image, potentially resulting in an abnormality being ascribed to the wrong structure.

- It may be due to Involuntary Motion (breathing, bowel motility, distension of the bladder) or Voluntary Motion (patient motion) and can result in both false-positive or false-negative PET findings if not identified and corrected appropriately.

# Misregistration

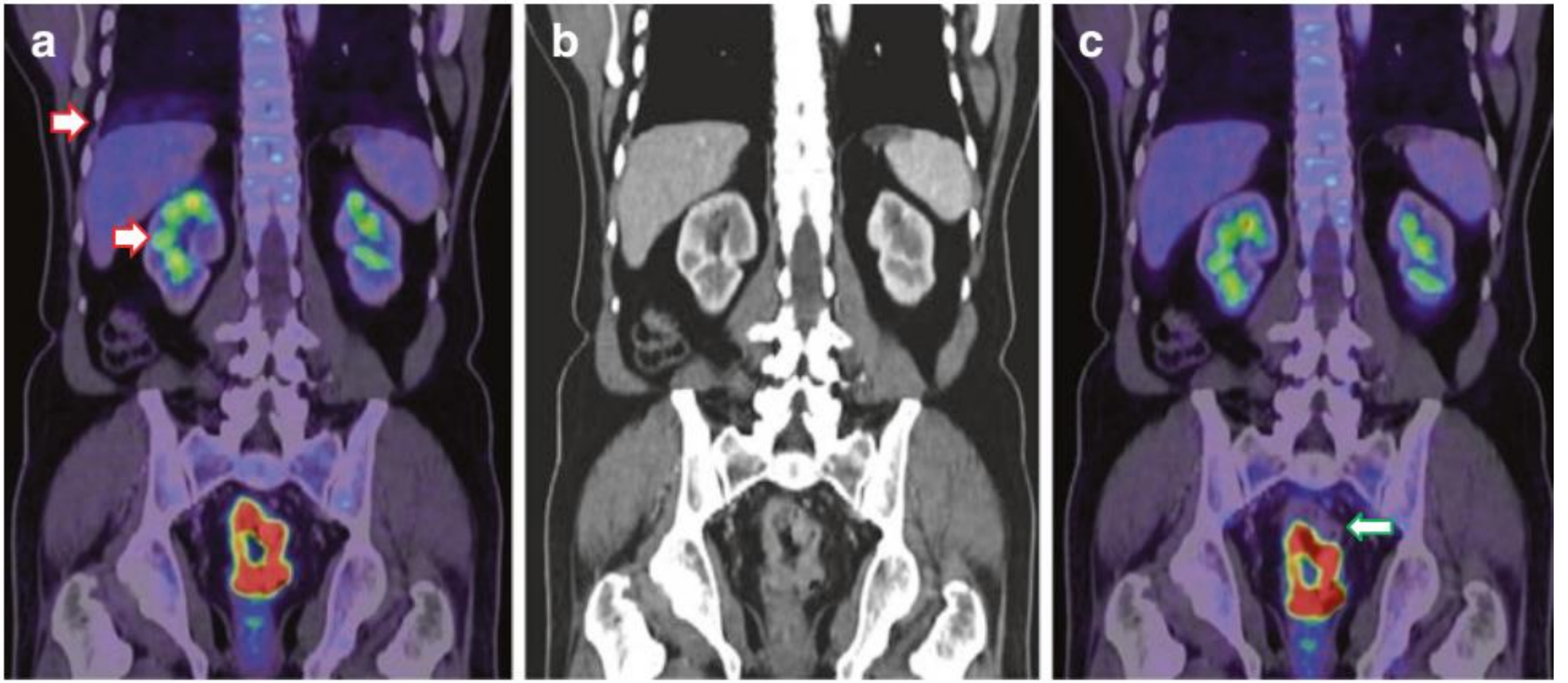



Figure. Misregistration of liver and renal FDG uptake (**a - coronal fused PET/CT, b – corornal contrast enhanced CT**) due to respiratory movement (***red arrows***). (c) Images after manual correction for misregistration of liver and renal activity, but it induces misregistration at the site of pathological FDG uptake in the lesion in the rectum (***green arrow***). Care should be taken while interpreting images with misregistration

# Misregistration

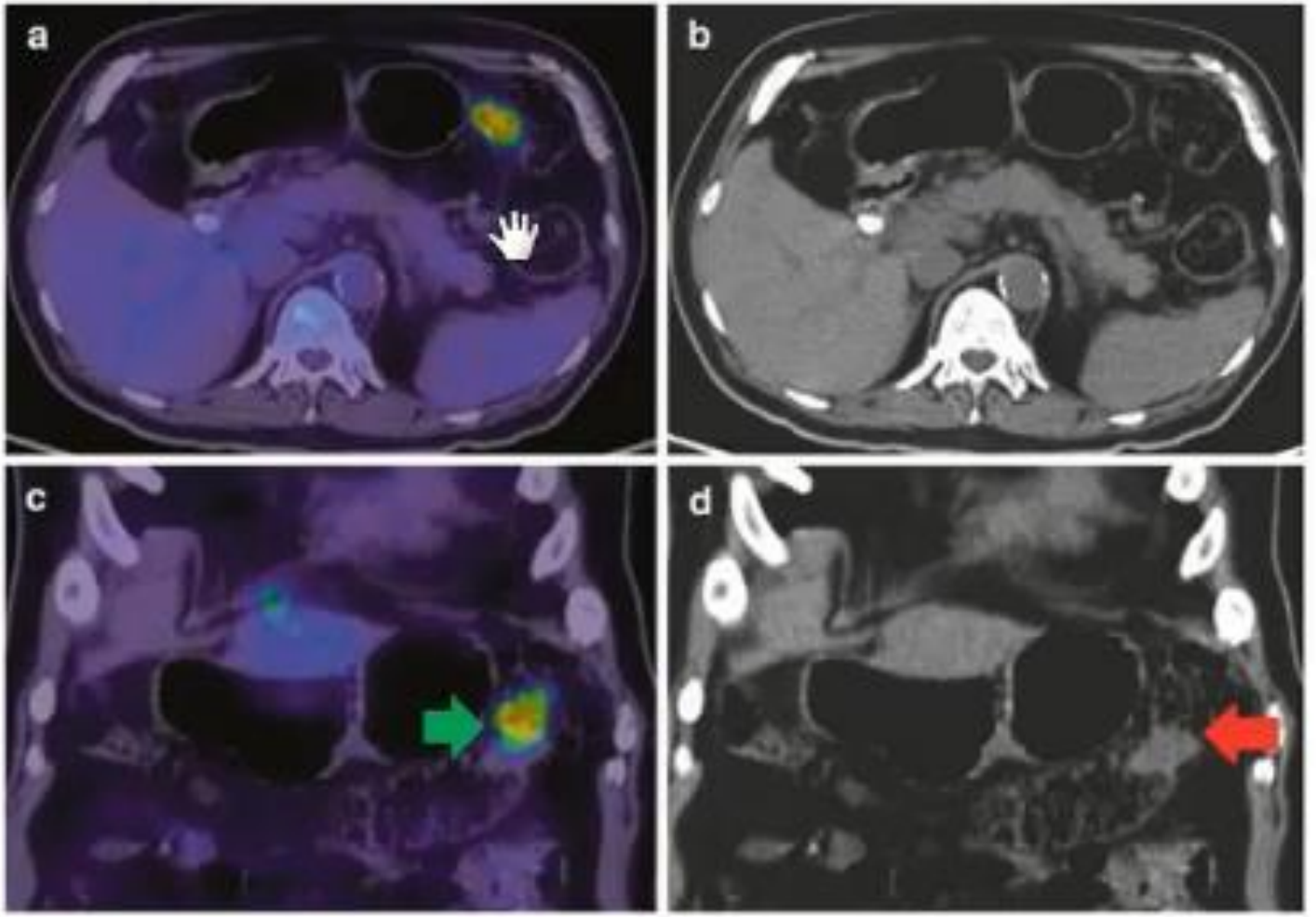
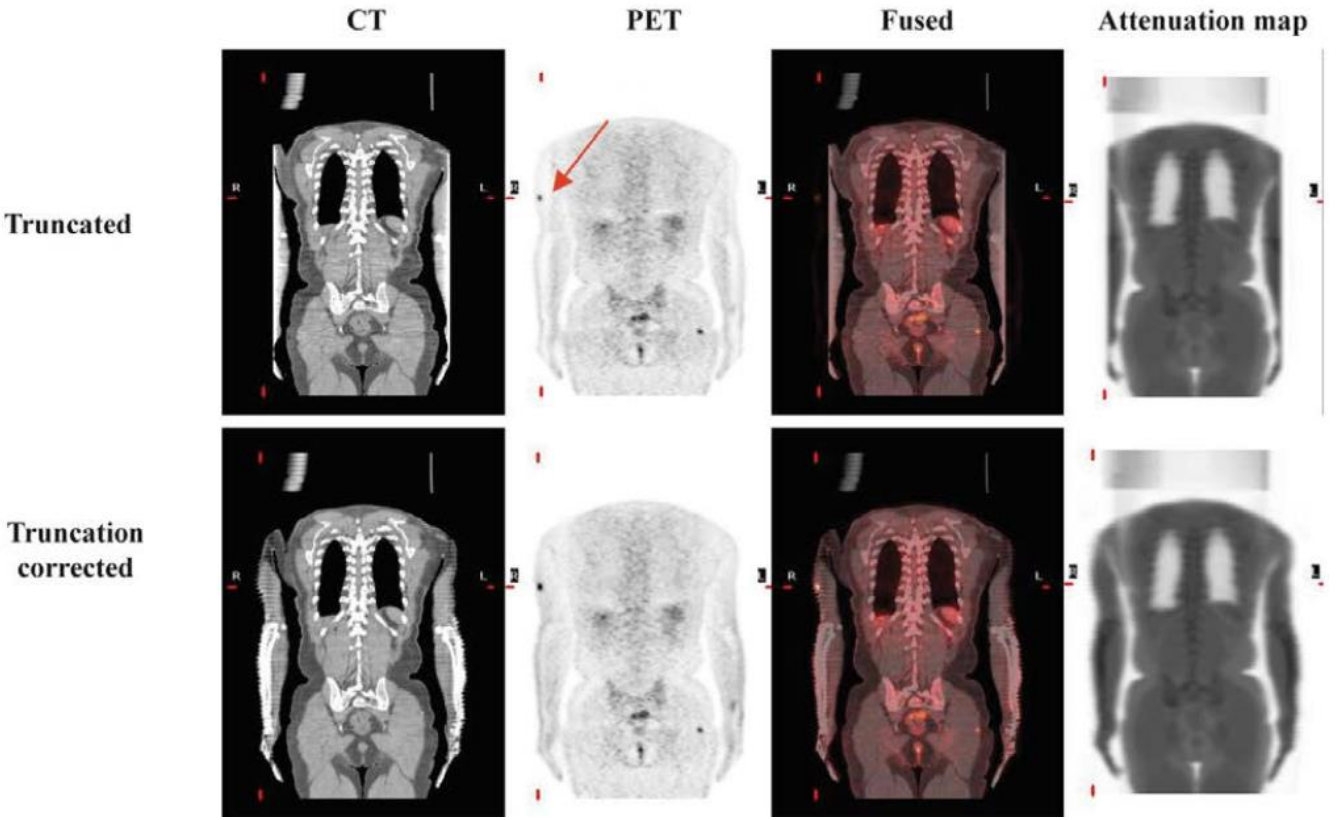



Figure. Misregistration due to bowel movement. Intensely FDG concentration in the left third of the transverse colon (a) with no corresponding lesion seen in CT (b). Careful review of coronal images (c - coronal fused PET/CT and d - coronal CT images) reveals the misregistration (**green arrow**—FDG uptake and **red arrow**, lesion in CT)

# Truncation Artefacts

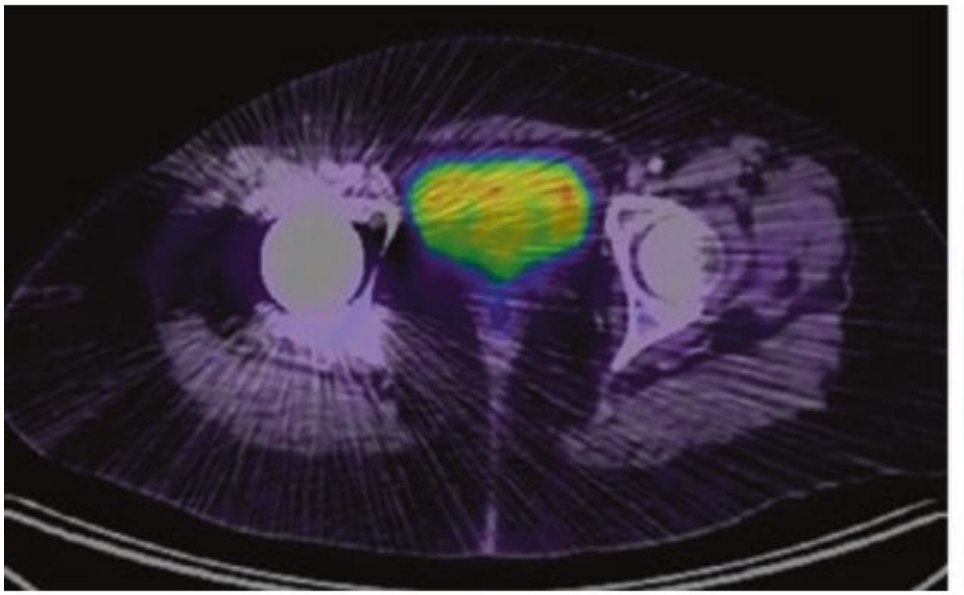
- Truncation artefacts in PET/CT are essentially due to the **difference in size of the axial field of view** between the **CT (50 cm)** and the **PET (70 cm)** tomographs.

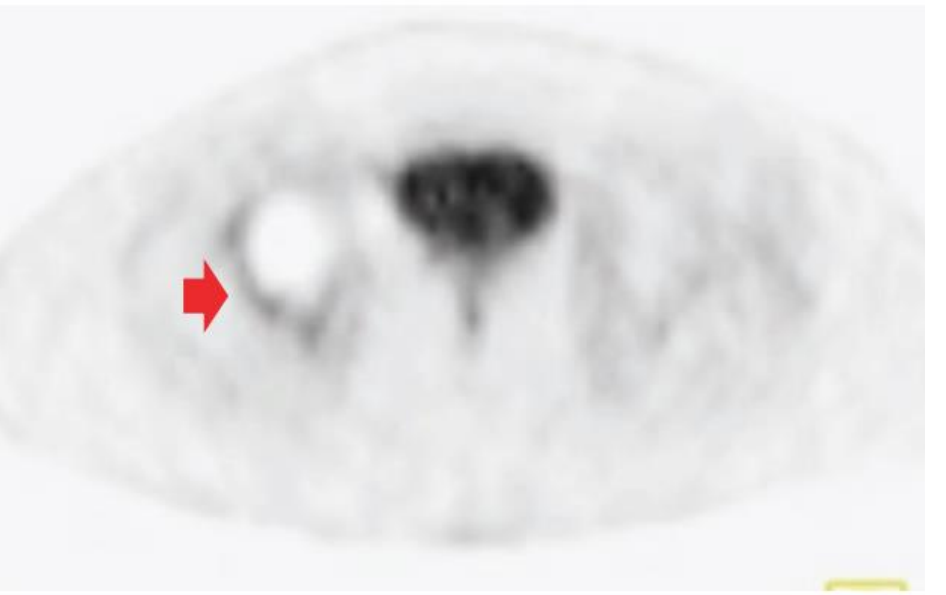


# Attenuation Correction Artefacts

Attenuation correction artefacts are seen in the presence of highly attenuating objects like

- Metallic Implant (metallic prostheses/ stents)

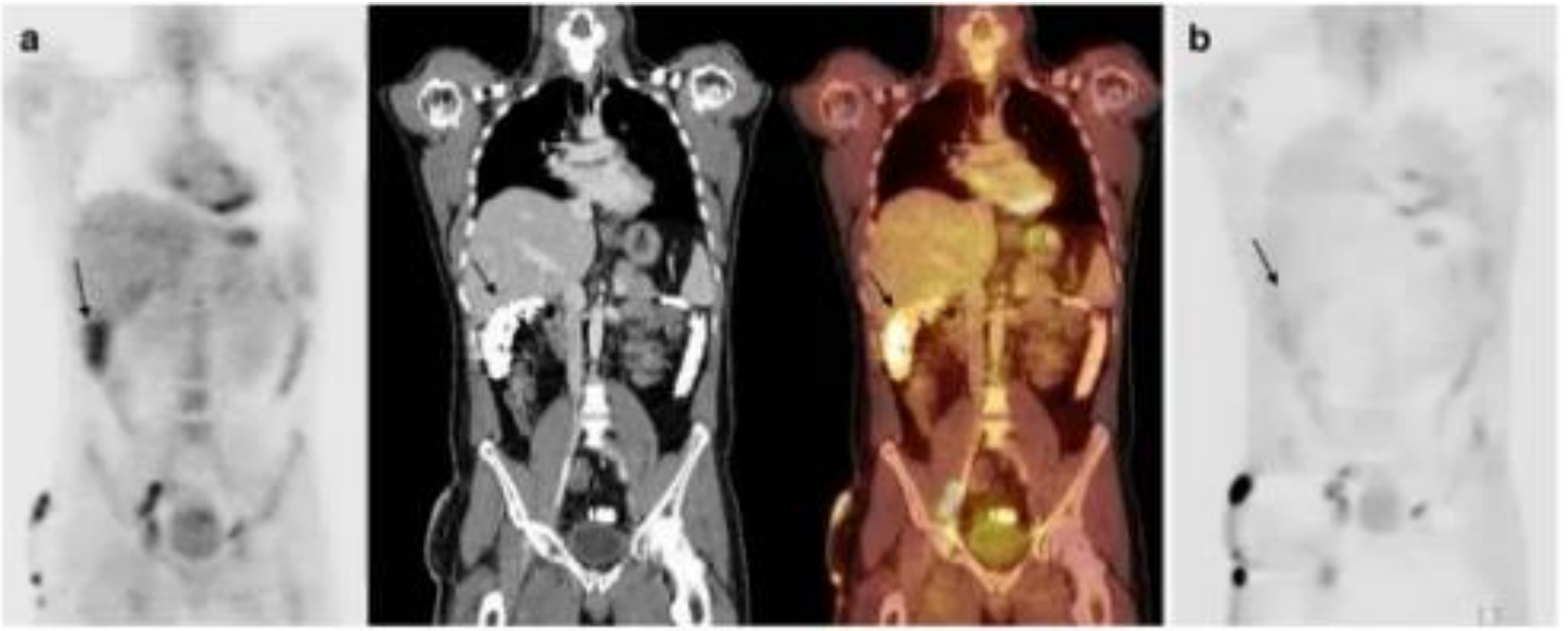




# Contrast Medium

Attenuation correction artefacts are seen in the presence of highly attenuating objects like

- Metallic Implant (metallic prostheses/ stents)
- Contrast Medium (dense intravenous contrast in the path of the CT beam)



# Partial Volume Effect

- Partial volume effects (PVES) represent a major source of degradation in PET imaging, introducing large biases especially for small structures.
- Main contributing factors include the finite spatial resolution of PET systems and the discrete sampling of reconstructed images.

# Outline

- Technical Artifacts in imaging
- Physiological Variants
- Organ- and Pathology-Specific Pitfalls

# Physiological Variants

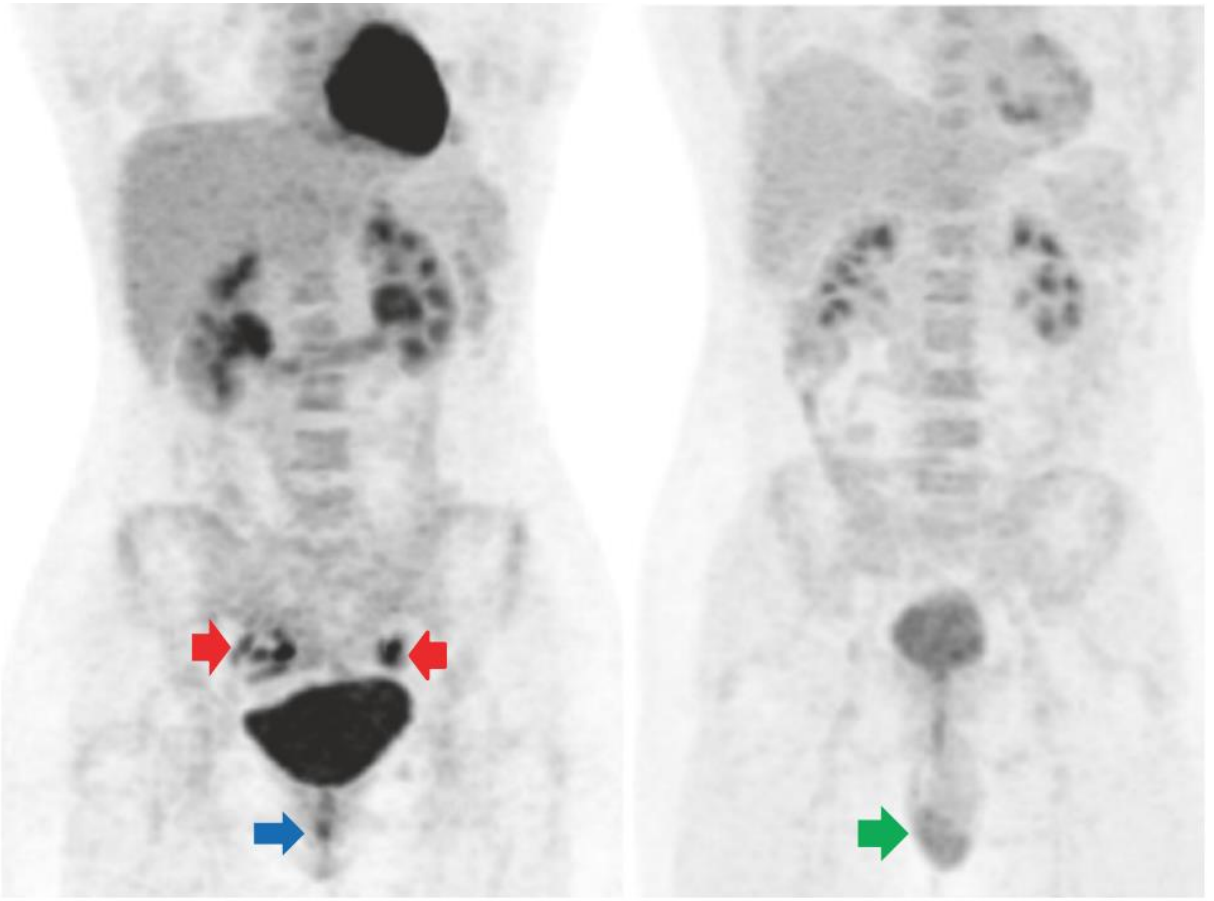


Figure. Physiological FDG uptake in the abdomen and pelvis: Usually most intense FDG activity is noted in the pelvicalyceal system, ureters, and urinary bladder. Physiological but less intense FDG uptake is noted in the liver, spleen, bone marrow, and renal cortices. Physiological (variable) FDG uptake may be seen in the uterus and ovaries (***red arrows***) depending on the phase of menstrual cycle. Physiological (low to moderate grade) FDG uptake may be seen in the testes (***green arrow***). Focal FDG uptake at the anus (***blue arrow***) is due to sphincter activation or local inflammation.

# Physiological Variants

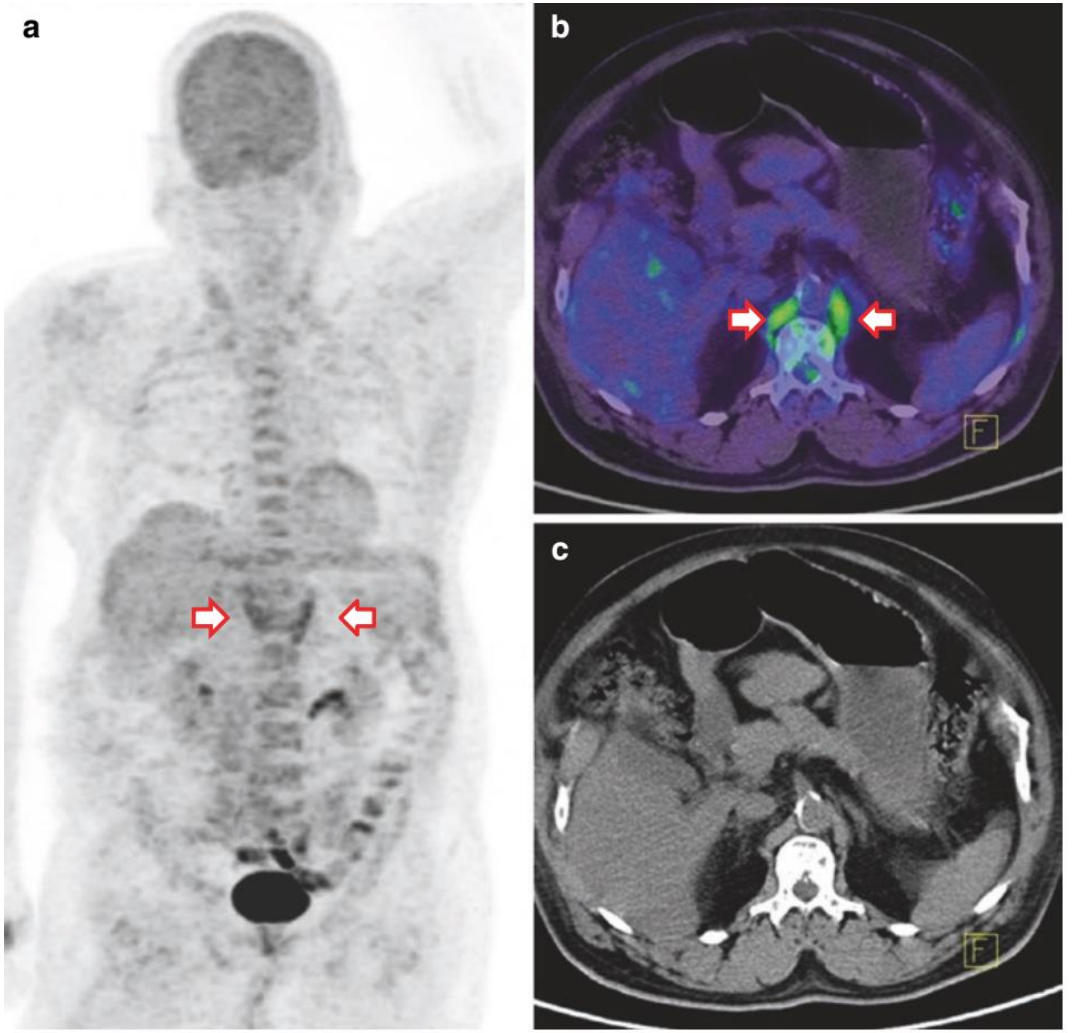



Figure. FDG uptake in bilateral diaphragmatic cruses (a - MIP). Physiological nature of the uptake can be ascertained by the symmetrical nature of FDG uptake (b) and absence of any lesion in the CT part (c)

# Physiological Variants

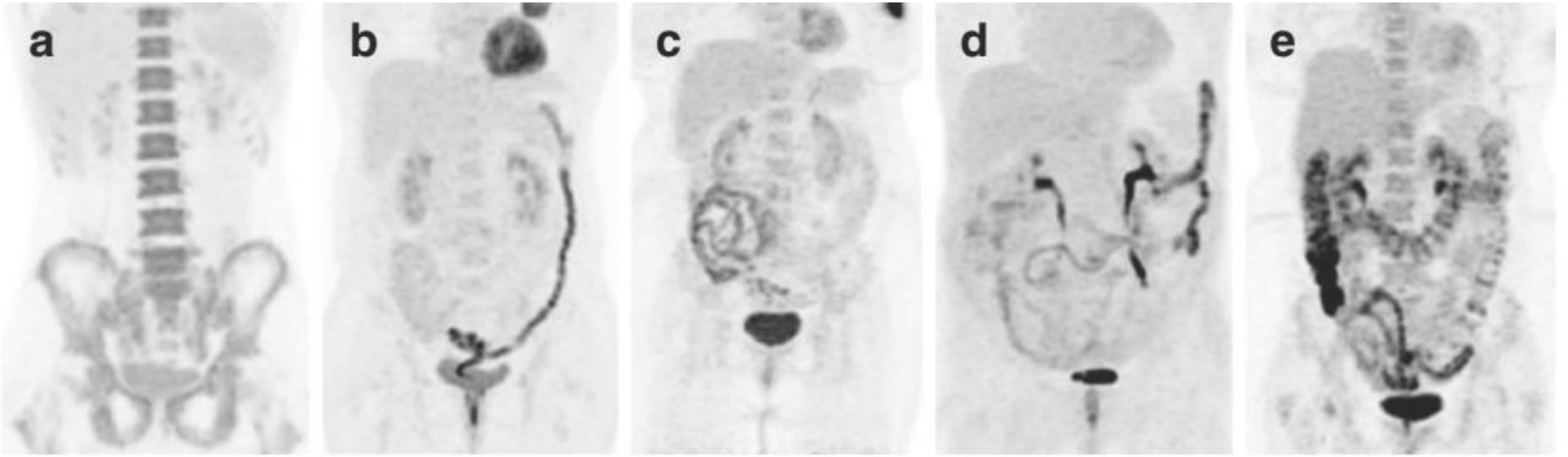



Figure. Physiological uptake pattern in large and small bowel. It can range from absent uptake (a) to segmental (b, c), patchy (d), or diffuse uptake (e)

# Liver

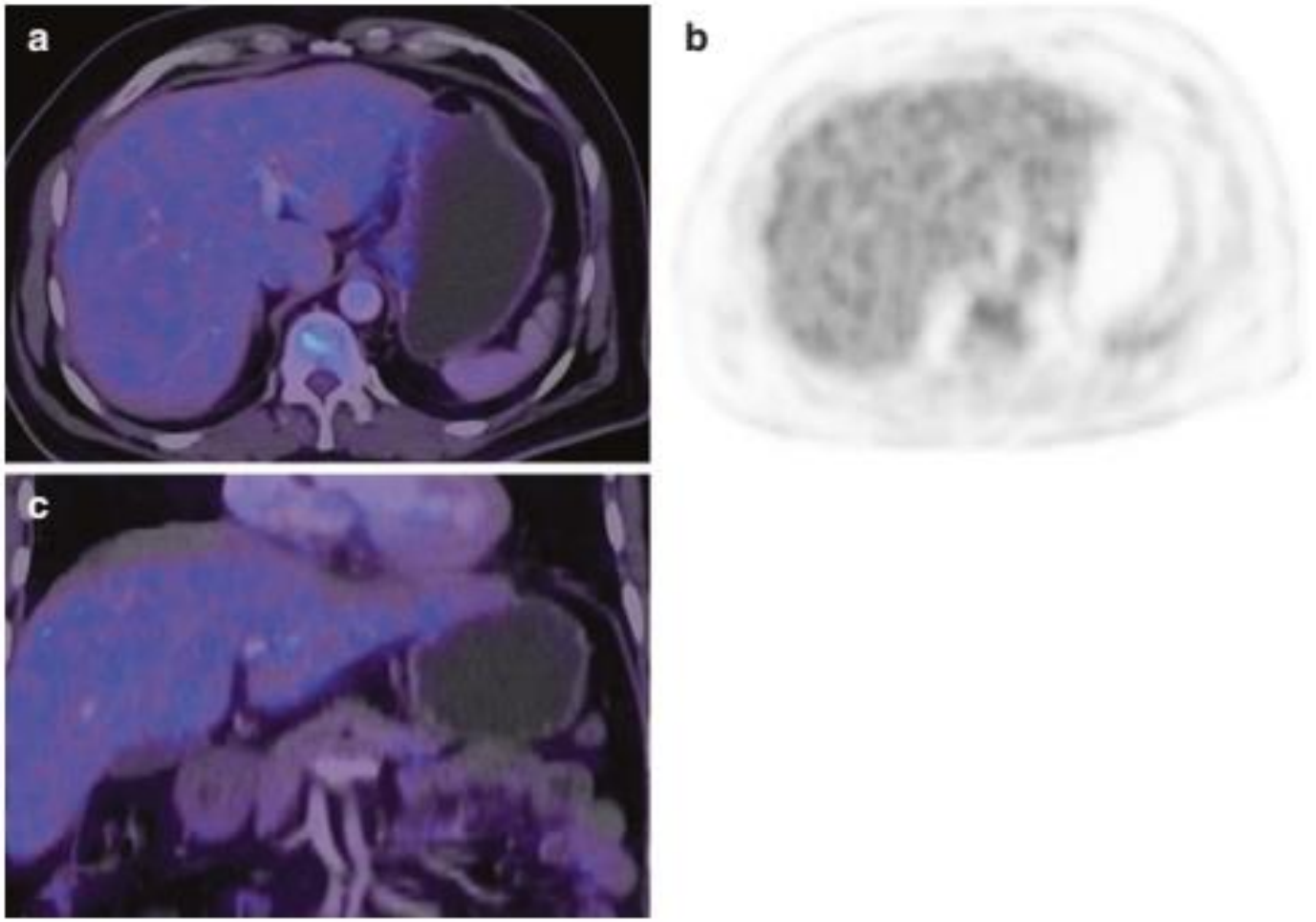



Figure. Physiological FDG uptake in the liver (a, c). Fine mottled appearance of physiological FDG uptake in the liver made out in PET image.

# Liver

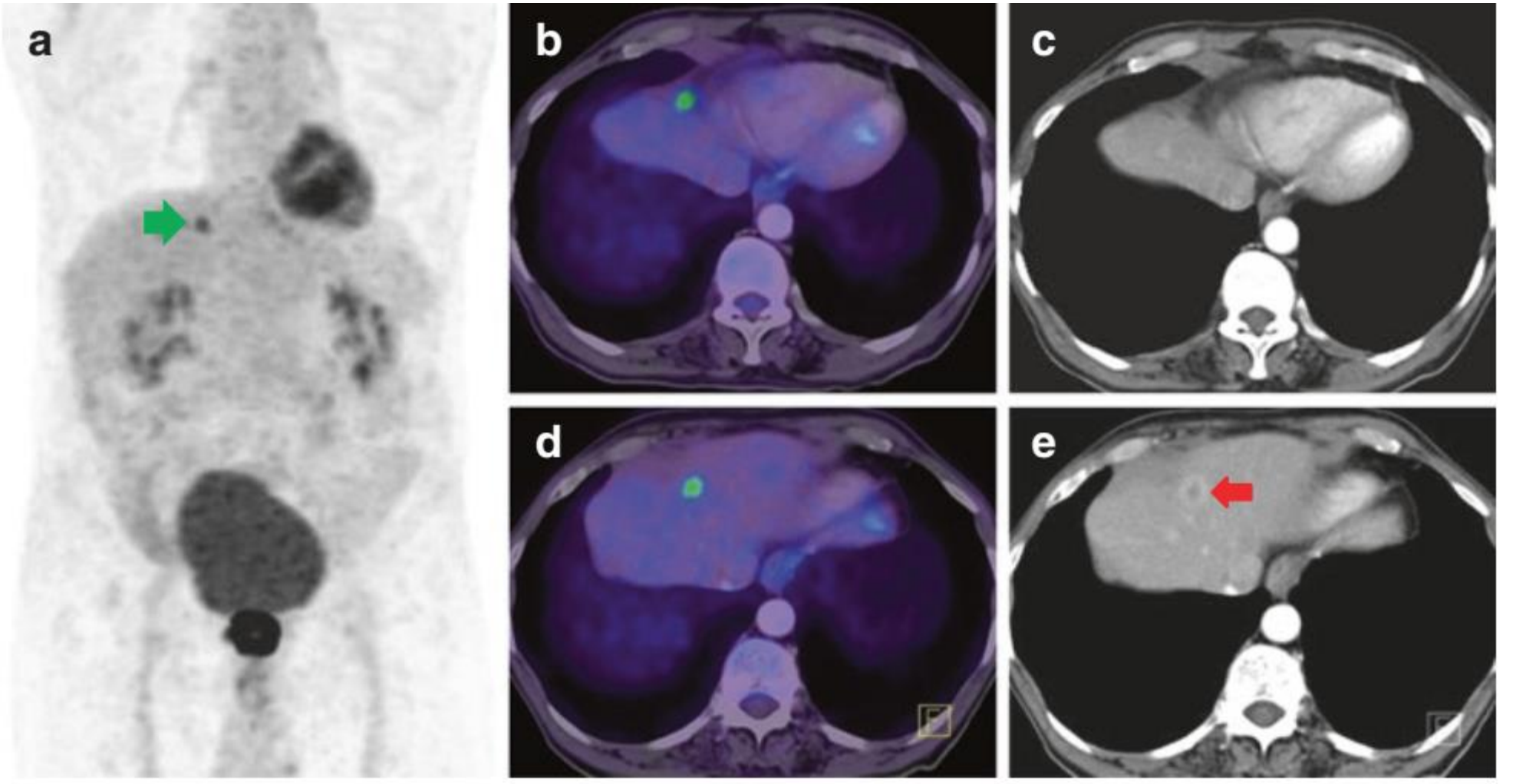



Figure. Case of carcinoma of the rectum 18F-FDG PET/CT for initial staging reveals focal FDG uptake in the liver (b) with no corresponding lesion seen in CT part (c). Review of MIP shows the lesion to be significant (**green arrow**) (a). Movement misregistration is manually corrected, and corresponding CT image shows a peripherally contrast-enhancing lesion in segment VIII of the liver (**red arrow**) (e)

# Liver

**False-positive** and **false-negative** FDG **uptake** in the **liver** with relevance to cases of colorectal malignancies

| False Negative | False positive |
|---|---|
| Lesions smaller than resolution of PET | Liver abscess |
| Necrotic and mucinous metastatic adenocarcinoma | Infarct |
| Post-chemotherapy | Granulomatous diseases |
| Coexistent hepatomas/infiltrative subtype of cholangiocarcinoma | Cholangitis (uptake along the biliary tree |

# Spleen, Pancreas, and Adrenals

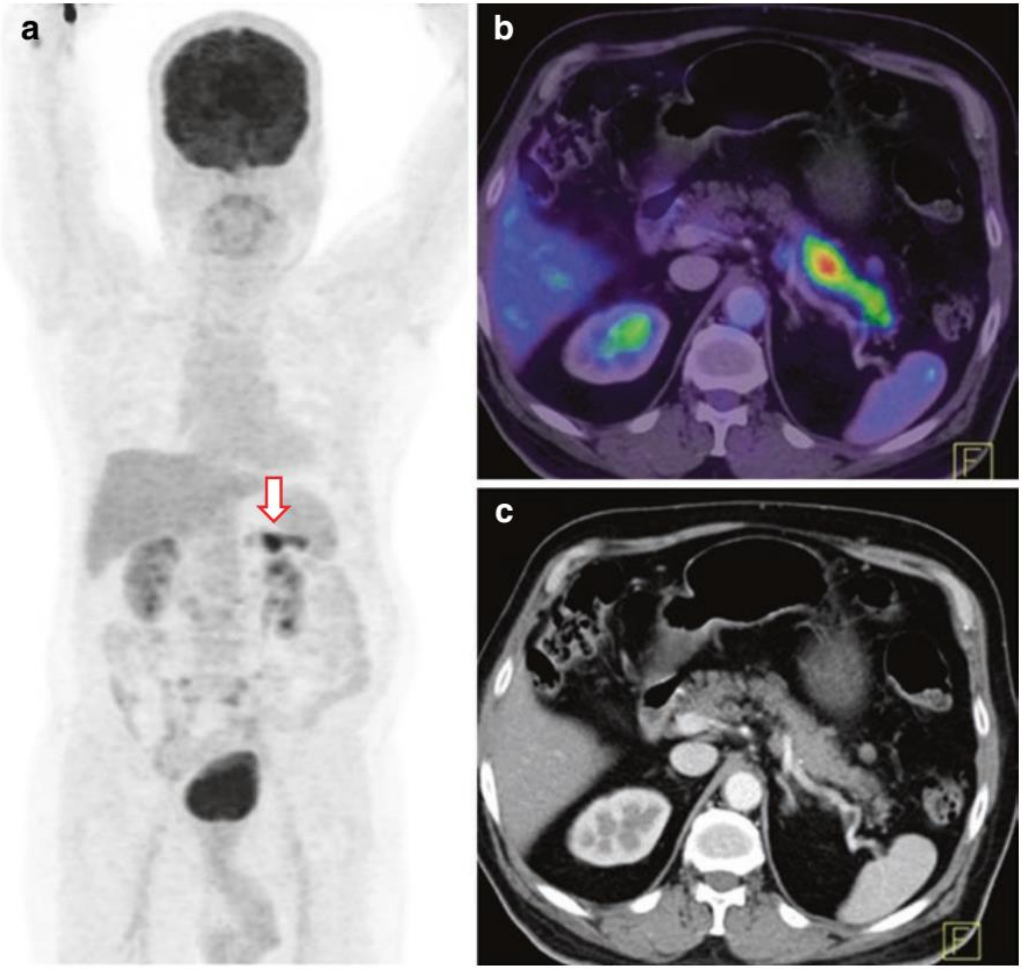



Figure. A 73-year-old male patient who was a treated case of carcinoma of the rectum, on follow-up, mild rise in CEA levels was noted. 18F-FDG PET/CT (a - MIP) was done for suspected recurrence which showed abnormal intense FDG uptake on distal body and tail of pancreas (b -axial fused PET/CT and c - axial contrast enhanced CT) with no abnormal FDG avid lesions elsewhere in the body. CA19-9 levels were marked elevated. Distal pancreatectomy was done, and histopathology report revealed primary pancreatic adenocarcinoma FDG uptake in the liver (a, c). Fine mottled appearance of physiological FDG uptake in the liver made out in PET image.

# Spleen, Pancreas, and Adrenals

**Causes of focal/diffusely increased FDG uptake in the spleen and pancreas**

| Spleen | Pancreas | Adrenals |
|---|---|---|
| Lymphoma | Primary pancreatic malignancy | Adenoma |
| Myeloproliferative disorders | Pancreatitis | Hyperplasia |
| Sarcoidosis | Post-radiation changes | Oncocytoma |
| Infections—tuberculosis, kala-azar, malaria, infectious mononucleosis, etc. | Portal vein thrombus | Angiomyolipoma |
| Chemotherapy | Haemorrhagic pseudocysts | Pheochromocytoma |
| Exogenous marrow stimulation | Retroperitoneal fibrosis | Paraganglioma |
| Metastasis | Metastasis | Metastasis |

# Colon and Small Bowel

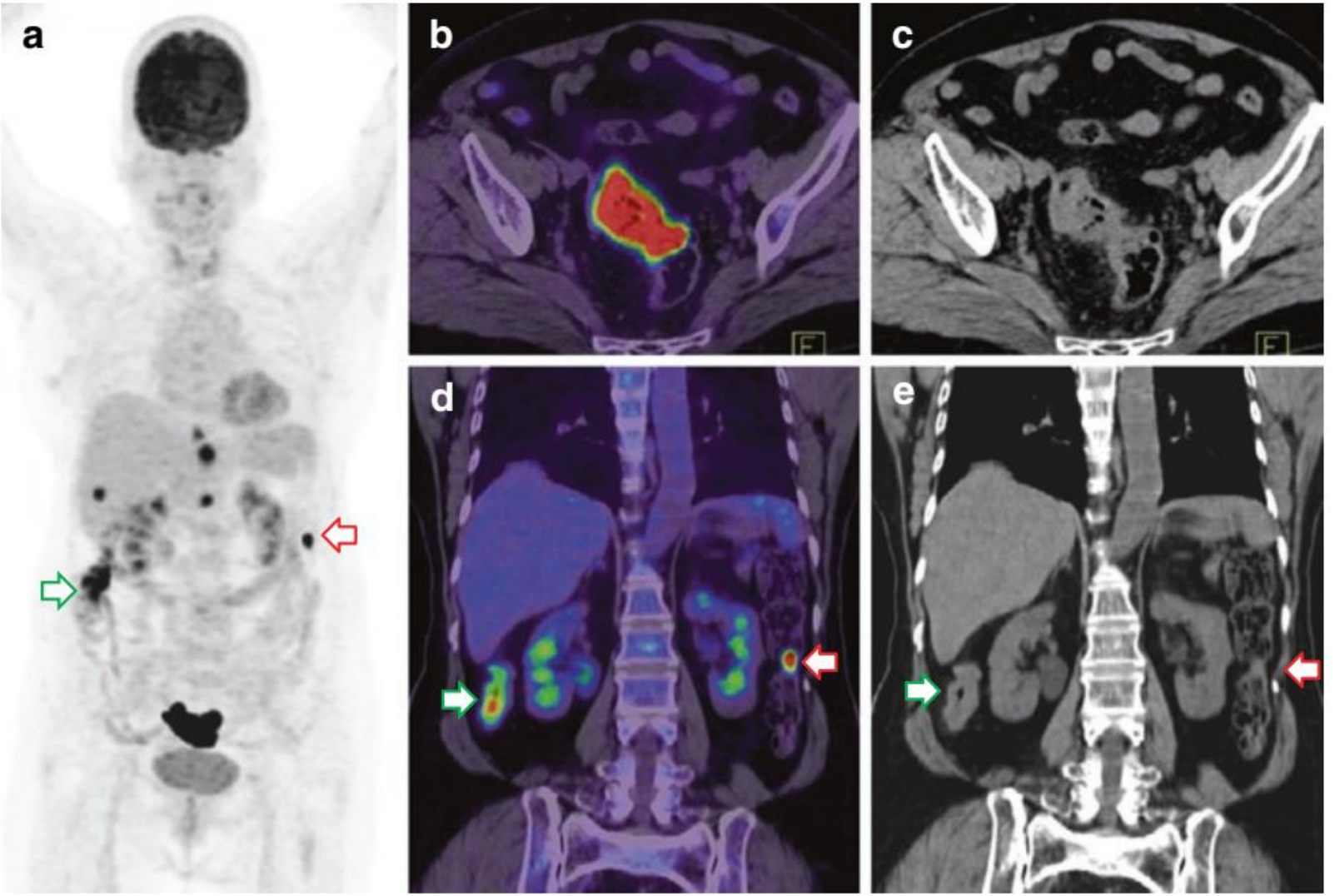



Figure. A 71-year-old female with diagnosed carcinoma of the sigmoid colon

# Colon and Small Bowel

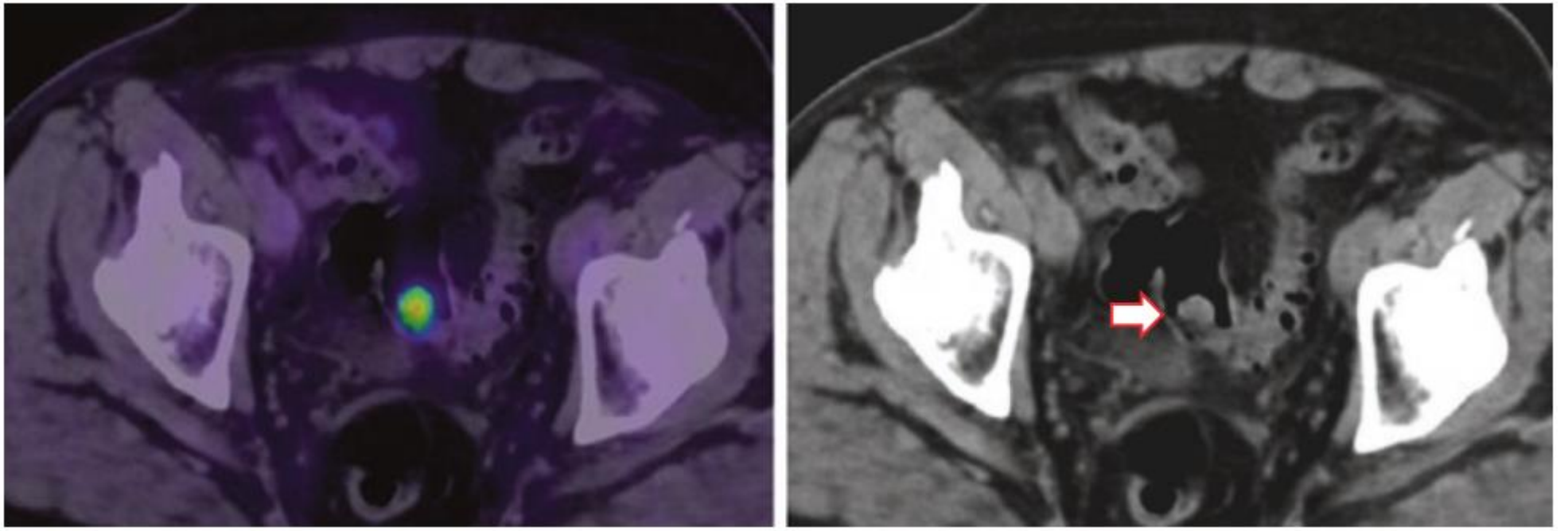
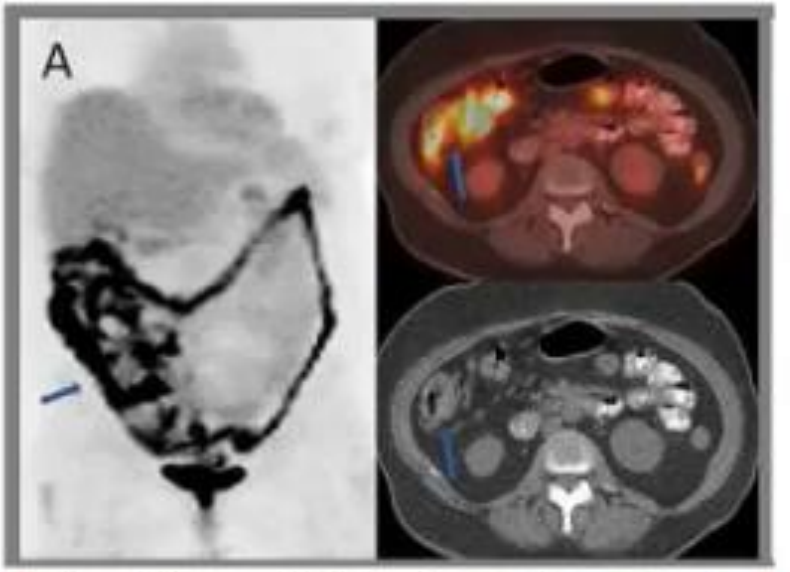


Figure. Incidentally detected intense FDG uptake in a sigmoid polyp (**red arrow**), which on colonoscopy and biopsy was found to be malignant.

# Colon and Rectum

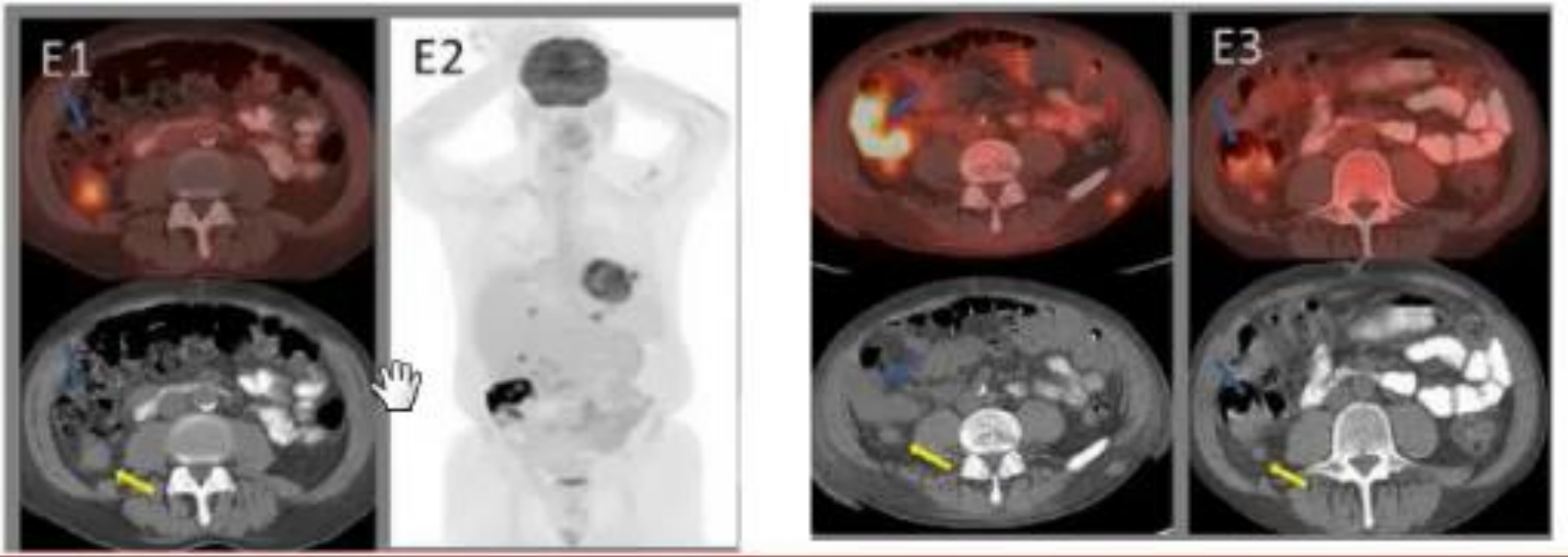
| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Colon and Rectum | FDG | Physiologic uptake, metformin bowel, colonic or ileostomy stoma, polyps, diverticulitis, IBDs, colitis, Inflammatory pseudotumor, sarcoidosis, normal appendix<br>Anastomotic uptake – physiological and inflammation<br>Post-operative changes and complications such as fistula<br>Radiation induced inflammation | May not be helpful in staging of localized disease without metastases<br>Mucinous tumors can be low-grade<br>Can have false positive results for response assessment in neoadjuvant setting |




Intense diffuse uptake throughout the large bowel in patient on metformin

# Colon and Rectum

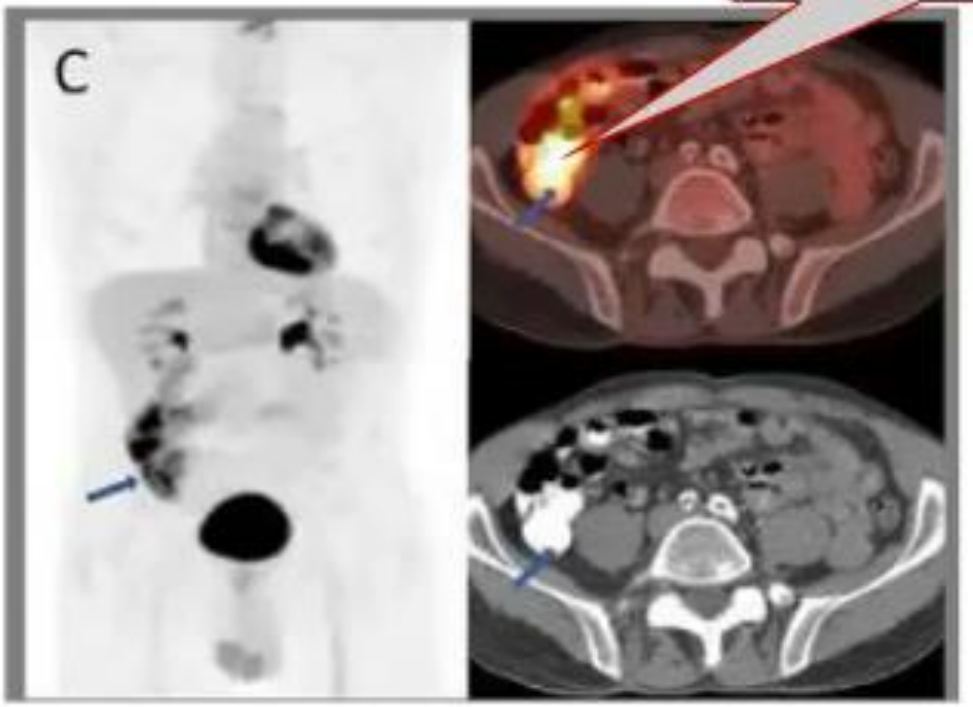
| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Colon and Rectum | FDG | Physiologic uptake, metformin<br>bowel, colonic or ileostomy stoma, polyps, diverticulitis, IBDs, colitis, Inflammatory pseudotumor, sarcoidosis, normal appendix<br>Anastomotic uptake – physiological and inflammation<br>Post-operative changes and complications such as fistula<br>Radiation induced inflammation | May not be helpful in staging of localized disease without metastases<br>Mucinous tumors can be low-grade<br>Can have false positive results for response assessment in neoadjuvant setting |




Post-radiation colitis of the hepatic flexure (E2) in a patient who underwent radiation therapy for a moderately intense right posterior peritoneal metastasis (E1; yellow arrows).Post-radiation, the nodule decreased in size; however, intense uptake is seen within the adjacent hepatic flexure (E2; blue arrows). Bowel uptake resolved on subsequent imaging with residual low-grade uptake within the peritoneal nodule (E3)

# Colon and Rectum

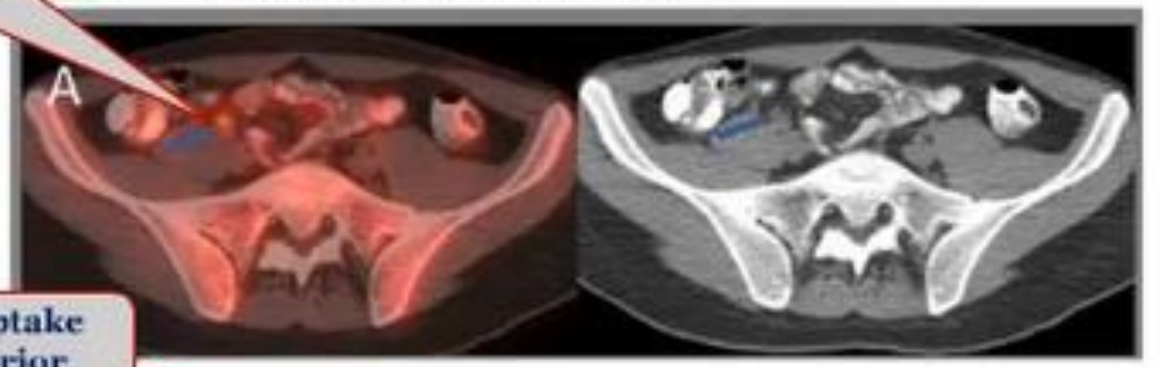
| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Colon and Rectum | FDG | Physiologic uptake, metformin bowel, colonic or ileostomy stoma, polyps, diverticulitis, IBDs, colitis, Inflammatory pseudotumor, sarcoidosis, normal appendix<br>Anastomotic uptake – physiological and inflammation<br>Post-operative changes and complications such as fistula<br>Radiation induced inflammation | May not be helpful in staging of localized disease without metastases<br>Mucinous tumors can be low-grade<br>Can have false positive results for response assessment in neoadjuvant setting |



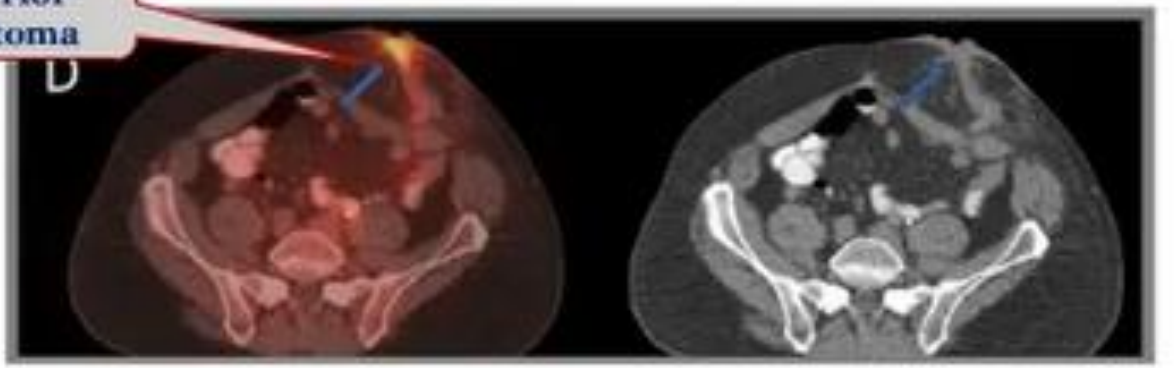
# Colon and Rectum

| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Colon and Rectum | FDG | Physiologic uptake, metformin bowel, colonic or ileostomy stoma, polyps, diverticulitis, IBDs, colitis, Inflammatory pseudotumor, sarcoidosis, normal appendix | May not be helpful in staging of localized disease without metastases<br>Mucinous tumors can be low-grade |
| | | Anastomotic uptake – physiological and inflammation | Can have false positive results for response assessment in neoadjuvant setting |
| | | Post-operative changes and complications such as fistula | |
| | | Radiation induced inflammation | |

Moderately intense uptake within a gas-filled normal appendix

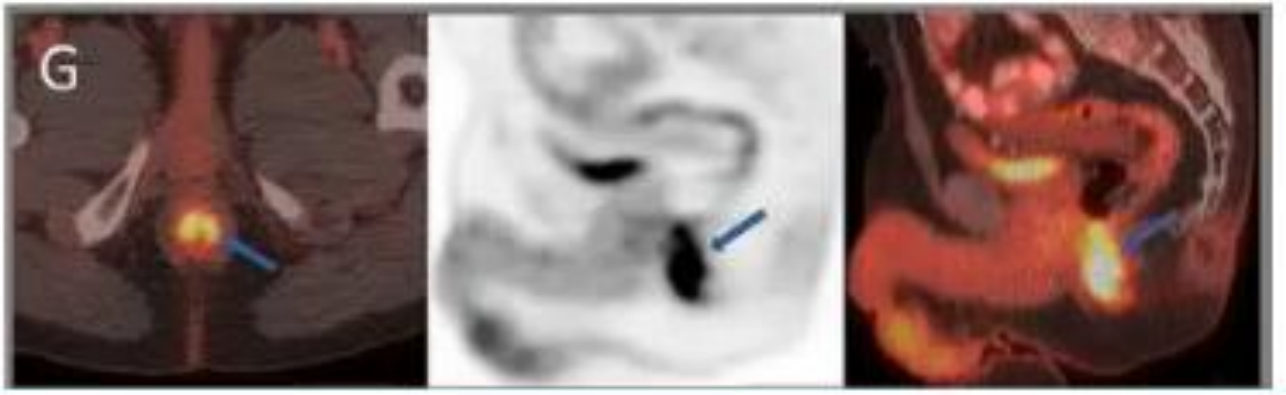



Benign intense uptake within a left anterior abdominal wall stoma



# Anal Canal

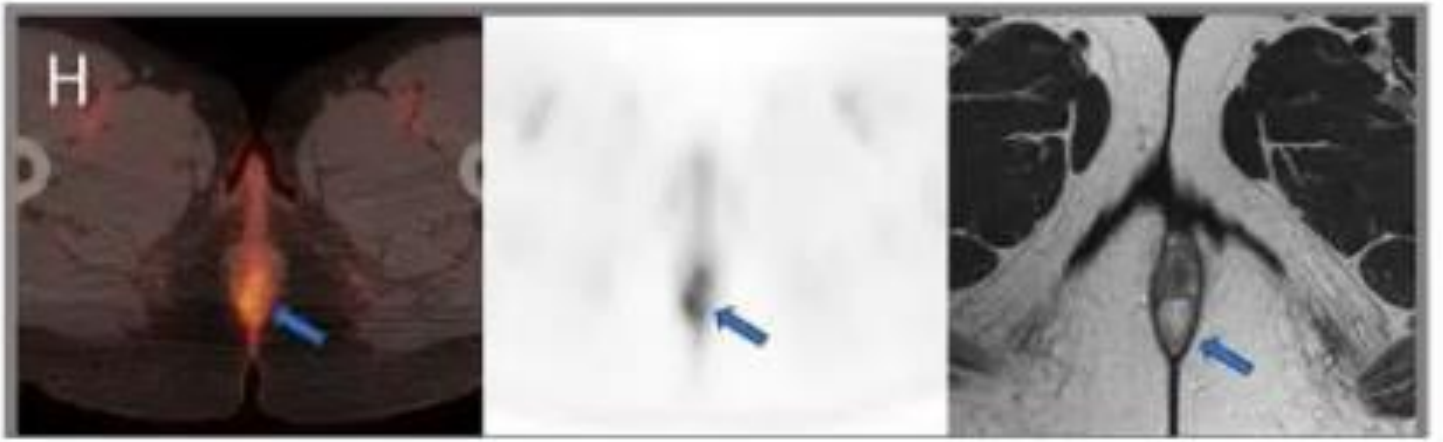
| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Anal Canal | FDG | Physiological, hemorrhoids, anal fistulas<br>Radiation induced inflammation | Not recommended for routine follow up; can have false positive results<br>Not for local staging of primary tumor<br>Can be false positive if performed soon after chemoradiotherapy<br>Role in follow up unclear – uptake within the anal canal on follow up does not necessarily indicate recurrence |




Physiologic intense uptake within the anal canal in a patient undergoing 18F-FDG PET/CT for head and neck cancer

# Anal Canal

| Site | Tracer Used | Benign Conditions That Can Mimic Malignancy | Malignant Conditions With Unreliable or Low-Grade Uptake |
|---|---|---|---|
| Anal Canal | FDG | Physiological, hemorrhoids, anal fistulas<br>Radiation induced inflammation | Not recommended for routine follow up; can have false positive results<br>Not for local staging of primary tumor<br>Can be false positive if performed soon after chemoradiotherapy<br>Role in follow up unclear – uptake within the anal canal on follow up does not necessarily indicate recurrence |




Moderately avid internal/external hemorrhoids at the anal verge as seen on MRI and also noted on clinical examination


Thanks for your kind attention!