Innocent abdominal sparkles: Benign, physiological and false positive findings in PET CT abdominal studies.

Poster No.: C-1450
Congress: ECR 2016
Type: Educational Exhibit
Keywords: Pathology, Infection, Artifacts, Physiological studies, Normal variants, PET-CT, Nuclear medicine, Anatomy, Abdomen
DOI: 10.1594/ecr2016/C-1450
Learning objectives

-To recognize various normal anatomical variants and common physiological findings in abdominal PET-CT studies

-To distinguish non-malignant findings from malignant diseases in PET-CT studies
Background

Ever since 2004, when positron emission tomography-computed tomography use became more widely extended, PET-CT has been a valuable tool, improving diagnostic accuracy compared with PET alone, and increasingly become the routine and preferred diagnostic procedure in many known or suspected cancers. (1)

PET-CT permits the early detection of increased metabolic activity in diseased tissues which may seem morphologically healthy. It is used for diagnosis, staging and follow up of multiple malignant conditions.

Malignant cells have an augmented utilization of glucose secondary to an upregulation of hexoquinase activity, in which the uptake in glucose, and therefore FDG-6-phosphate, is proportional to their metabolic activity (1).

The combination of CT, which provides an accurate anatomic localization to the increased metabolic activity foci on PET, allows a more precise and reproducible disease correlation.

We’ve reviewed general interpretation problems that arise during routine PET-CT scans, including physiologic uptake as well as multiple frequent benign diseases that can confuse the interpreter.

We also illustrate a variety of specific interpretation issues, including issues relating to specific anatomic locations (eg, liver and spleen; kidneys, ureters, and bladder; pancreas and adrenal glands; gastrointestinal tract; reproductive tract; bone). (1)

In most case reviews of PET-CT, there is about a 25% of benign non-physiologic uptake, with approximately 75% of those being of inflammatory nature. Increased deposit of FDG in inflammatory diseases can be at least partially explained by the recruitment of activated white blood cells, which increases glucose metabolism. Studies have shown that fusion of CT and PET data improves the sensitivity and specificity. Nonetheless, in many cases a histological sample is fundamental for adequate diagnosis. (2)
Findings and procedure details

Misregistration

This term describes the superimposition of FDG activity on equivocal anatomic structures seen at CT, causing false positive or negative findings superimposed on the wrong tissue. It is mostly secondary to movements, such as breathing, bowel motility or voluntary movements.

It can be reduced by permitting normal breathing pattern during the CT and PET acquisition phases. (1) Fig. 1 on page 9

Nonneoplastic Hypermetabolic Lesions

All hypermetabolic lesions do not imply malignancy, as inflammation, granulomatous disease and postoperative findings, as well as benign neoplastic lesions can all show increased 18FDG uptake. (1).

Most findings can be differentiated with the CT component, diminishing false positive interpretations.

Surgical procedures produce an important inflammatory response that is seen as an area of augmented activity on PET, evident for weeks after, which is the reason PET-CT studies should be delayed 6-8 weeks. (1 and 5)

Radiation therapy (5), often used to treat different malignancies, especially those that have highly proliferative cells, also affects healthy tissue that surrounds the malignancy, causing injury; PET-CT scans should be delayed 8-12 weeks to heighten it’s diagnostic sensibility. Fig. 2 on page 9

Chemotherapy (5) damages rapidly dividing cells but is not malignancy specific, affecting other healthy tissues in the process.

As previously mentioned, active granulomatous processes, especially where macrophages and neutrophils are present, such as sarcoidosis or tuberculosis, can lead to false positives, as well as foreign body reaction including mesh prosthetics, which can persist even after several years. Correlation on CT images can aid in their correct interpretation (7). Fig. 3 on page 10
Liver and Spleen

Typically, liver uptake is moderately intense with a patchy appearance. The subdiafragmatic portion should be carefully examined, as breathing artifacts can cause misregistration, projecting the uptake onto the lung base. Fig. 1 on page 9

Multiple benign liver lesions can present with increased uptake, as seen on images. Fig. 4 on page 11 Fig. 5 on page 11 Fig. 6 on page 12

The normal spleen has slightly less activity than the liver, and can present elevated activity during use of CSF treatments after bone marrow depletion during chemotherapy, as well as sarcoidosis (4). Fig. 7 on page 13

Biliary system

A normal biliary system does not present with increased FDG activity, yet most inflammatory diseases will present increased uptake on PET. Here, we present a case of acute cholangitis. Fig. 8 on page 14

Pancreas

The pancreas has a low 18FDG uptake, and false-positive results for pancreatic cancer can also occur in chronic active pancreatitis, irradiated tissue and autoimmune pancreatitis, which have moderate uptake of 18FDG. Meanwhile, intense focal activity must be distinguished from inflammation in acute pancreatitis (8) Fig. 9 on page 15. Other more rare causes of moderate uptake include portal vein thrombosis, hemorrhagic pseudocysts, peripancreatic lymph nodes, and retroperitoneal fibrosis.

Adrenal Glands

Normal adrenal glands are not visible on PET (5).

Adrenal hyperplasia or more rarely adenomas and myelolipomas can present with significant uptake. Another adrenal pitfall can be due to brown fat, simulating a malignant lesion. Benign lesions usually have lower activity than the liver (1).

Retroperitoneum

The presence of brown fat is a relatively common pitfall, diminished by a careful CT correlation, usually sufficient to distinguish these findings (1).

The great vessels must also be examined, noting that aneurysms Fig. 10 on page 16 or their repair may have elevated activity, as well as vasculitis Fig. 11 on page 17 (6).
Acute vein thrombosis, confirmed on CT component, if benign will have peripheral uptake; if malignant the thrombus will have diffuse uptake. Fig. 12 on page 18

**Kidneys and Urinary Tract**

Since 18FDG is excreted by the renal tubules, the intrarrenal collecting systems, ureters and bladder have intense activity (8). In particular, hydronephrosis due to calculus Fig. 13 on page 19 or external compression, dilated or redundant ureters and bladder diverticula can cause confusion in PET interpretation and can be reduced by correlating with the CT component (6).

Common inflammatory disease such as pyelonephritis and absceses located in the perirrenal spaces can also present as a hypermetabolic finding on PET-CT, and must be correlated on CT images.

Benign tumors may also present with moderate FDg uptake. Fig. 14 on page 20

**Gastrointestinal Tract**

FDG uptake is highly variable and mostly non-specific, and many times hidden by normal physiological deposits. Ideally, studies are done with negative oral contrast material, thus avoiding the potential issues with attenuation artifact that can be seen with high-density barium based oral contrast (1).

Physiological uptake of the bowel can be due to metabolically active smooth muscle tissue, mucosa, swallowed secretion or microbial uptake and usually has a linear appearance. In the right lower quadrant, uptake can also be secondary to the high concentration of glucose-metabolizing lymphatic cells that surround the ileum, cecum and ascending colon. Fig. 15 on page 21 Use of metformin also presents an increase of bowel activity (8). Fig. 16 on page 22

In general, inflammatory processes tend to have a segmental uptake (4).

The esophagus generally has a low 18FDG uptake, and common pitfalls include inflammation, mainly ulcers or esophagitis. Post radiation esophagitis, mostly seen with non-small cell lung carcinoma or thoracic node disease, occurs typically at week 3-4 after the therapy (5).

Homogeneous increased uptake in the stomach wall and gastroesophageal junction is relatively common, but can be exacerbated if in the presence of gastritis (8). Fig. 17 on page 23

Small bowel uptake is variable but usually of low grade, less than SUV 4.0 (8).
Acute appendicitis Fig. 18 on page 24 and diverticulitis Fig. 19 on page 25 are common inflammatory diseases that cause localized FDG uptake.

**Uterus**

Endometrial uptake is cyclical in premenopausal women, being higher during ovulation and menstruation.

Uterine fibroids can also present with increased activity. Fig. 20 on page 26

After menopause, all endometrial uptake is abnormal (1).

**Ovary**

Ovaries may display physiological FDG activity, more noticeable in premenopausal women, seen as uptake during ovulation and due to a corpus luteum cyst, which appear as small, rim-enhancing cysts at contrast-enhanced CT (1).

Most postmenopausal uptake is abnormal.

Postsurgical changes in the pelvis can make CT interpretation difficult, adding benefits to using PET-CT in these patients.

**Prostate Gland**

Most prostate adenocarcinomas are hypometabolic, which difficults their evaluation. Nonetheless, local recurrence, lymph node and bone metastases are facilitated by PET-CT (1).

**Bone**

Bone marrow usually has a low FDG uptake with a SUV of less than 3.0. (8). Bone marrow is often suppressed in chemotherapy use, with resulting pancytopenia and is treated with colony-stimulating factors, which cause a diffuse increased activity of bone marrow (5), also seen with use of EPO in anemic patients.

PET and CT are complementary, as PET better displays marrow disease and CT cortical based lesions.

The most common benign bone uptake is seen with degenerative spondylitis, though Paget disease and fibrous dysplasia can also present with higher uptake during their active phases and are more recognizable at CT (1). Fig. 21 on page 27 Fig. 22 on page 28
Lymphatic system

Most inflammatory and malignant lymph nodes will present increased FDG uptake, this limited specificity is the reason those findings must be correlated to other findings, especially those on CT component, to be properly interpreted. Fig. 23 on page 29 Fig. 24 on page 30
Fig. 1: Misregistration artifact as seen on fused PET-CT image (C), which shows as FDG activity on the right lung base (arrow), produced by respiratory movements which displaces normal liver activity to this localization.

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Fig. 2: 69 year old female, diagnosed with cervical cancer and was treated with pelvic radiation therapy. Axial CT (A), PET (B) and fused PET-CT (C) show respectively a diffuse wall thickening of a short segment of ileum and a long segment of sigmoid colon, compatible with postradiation changes.

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Fig. 3: 83 year old female patient diagnosed with colon cancer and liver metastases that were surgically resected. In follow up PET CT scans, there was a hypoattenuation liver lesion in the surgical bed on CT images (arrow on A), which presented with increased
uptake on fused PET CT (B), confirmed by biopsy to be compatible with a foreign body reaction granuloma.

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Fig. 4: 69 year old female. after a routine colonscopy discovered an infiltrating hepatic angle colonic lesion that had a negative biopsy, a PET-CT is ordered: images show a large homogeneous hepatic lesion on CT image (B), later confirmed as a hydatic cyst. It has peripheral FDG uptake on PET (A) and fused PET CT (C), a finding that confirms its viability.

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Fig. 5: 48 year old female treated with metotrexate for previous diagnosis of sarcoidosis, axial CT (A), axial PET-CT (B) and coronal PET show intense focal uptake in liver parenchyma which correspond to sarcoid lesions. Coronal PET (C) also shows perihiliar lung uptake also corresponding to sarcoidosis.

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Fig. 6: 41 year old male patient: PET-CT was indicated because of suspected liver metastases. On PET (A) we can see multiple hepatic lesions (arrows) that present with increased uptake seen on fused PET-CT (B). After surgery of the largest lesion, they were confirmed to be hepatic adenomas.

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Fig. 7: 41 year old female with breast cancer, coronal CT (A) shows an unremarkable and homogeneous spleen attenuation, while fused PET (B) shows an increased activity, higher than that of the liver, later confirmed as sarcoidosis.

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Fig. 8: 64 year old male treated for lung cancer. He was hospitalized to study recent jaundice and abnormal liver enzyme tests, with suspected liver metastases. On axial CT images (A and B) an intrahepatic bile duct dilatation is observed (arrow), with moderate FDG uptake (SUVmax 4.1) on fused PET-CT (C and D), interpreted as cholangitis.

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Fig. 9: 71 year old male in treatment for melanoma. On the day of the follow up PET-CT scan, the patient refers abdominal pain. The images show that there is a global enlargement of the pancreatic gland with adjacent fat stranding on CT (A), with diffuse increased FDG uptake on axial PET-CT (B) and coronal PET (C), findings are compatible with acute pancreatitis.

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Fig. 10: Coronal and axial CT (A-D) show a celiac trunk aneurysm (arrow) with mural thrombus and increased uptake on PET (B-E) and fused PET-CT (C-F) in a 69 year old female patient who has colon cancer.

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**Fig. 11:** 58 year old male diagnosed with giant cell arteritis with asymmetric upper extremity blood pressure. On axial (A) and coronal (E) CT images there are no important radiological findings, yet on sagital (B), coronal (D) and axial (F) fused PET-CT, as well as on coronal PET (C) there is an increased FDG uptake of the thoracic and abdominal aorta (arrows), interpreted as vasculitis.

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Fig. 12: 63 year old male hospitalized after a brain hemorrhage, and studied for fever of unknown origin. Coronal reconstruction CT scan (A) presents with a filling defect of the femoral (arrow) and inferior cava veins (not seen on included images) with subtle activity on fused PET CT (B), compatible with acute vein thrombosis. The peripheral uptake confirms a non malignant thrombus.

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Fig. 13: 83 year old male diagnosed with lymphoma and horseshoe kidney, visible on axial CT (A) and fused PET-CT (B). The day of the PET-CT scan, he was diagnosed with a right ureteral lithiasis (arrow on D) and secondary obstructive uropathy and urinoma located in the perirrenal space, seen as increased FDG uptake on PET (C) and fused PET-CT (D).

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Fig. 14: 74 year old patient, staging of rectal cancer. In earlier diagnostic CT scan (A), there was a cortical renal lesion (arrow), defined as a probable angiomyolipoma. In posterior PET-CT scan, patient refers intense abdominal pain. There was an intravenous contrast leakage into the right perirrenal space causing a hemoperitoneum as seen on axial (B) and coronal reconstruction CT (C), with subtle uptake on PET (D) and fused PET-CT (E), diagnosed as Wunderlich syndrome. He was treated by embolization with endovascular coils.

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Fig. 15: 53 year old female: Follow up PET-CT after being diagnosed with stomach cancer: Axial (A) and coronal CT (C) and axial (B) and coronal (D) fused PET-CT show physiological uptake in ileocecal valve (arrow).

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**Fig. 16:** 76 year old female with type 2 diabetes and in complete remission of cervical cancer. The PET (B) and fused PET-CT (C) images show diffuse FDG activity throughout the large bowels, due to metformin use. On CT images (A) there are no morphological findings in the large bowel.

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**Fig. 17:** Increased activity seen in the gastric camara in axial PET (B) and fused PET-CT (C) scan in a 57 year old female with a stage IV ovarian cancer diagnosis, physiological in nature. On CT (A) there is no remarkable gastric wall thickening nor morphological finding.

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Fig. 18: 86 year old breast cancer patient in hormonal treatment consults for lower right quadrant pain, non enhanced CT scan presents inflammatory changes surrounding the cecum and appendix, while fused PET CT (B) shows correlating increased radiotracer uptake, diagnosed as acute appendicitis.

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**Fig. 19:** 67 year old male diagnosed with a recurring lung cancer, coronal CT (A), PET (B) and fused PET show an abscess with avid peripheral uptake (arrow) secondary to acute descending colon diverticulitis.

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Fig. 20: Axial PET-CT scan in a 42 year old female with advanced breast cancer shows increased FDG uptake in the uterus (arrow), later confirmed as a uterine fibroid.

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Fig. 21: 65 year old female, studied for suspected bone metastases. Axial CT (A) image show bilateral articular space widening with lytic changes of the sacroiliac joint, with increased uptake on axial fused PET-CT (B). On fused PET-CT, we can also see increased activity of the pubic symphysis (C). Biopsy ruled out tumoral or rheumatic disease, and after isolating P. aeruginosa in a knee arthrocentesis and prolonged antibiotic treatment, the patient had a favorable outcome. Note the focal uptake in the subcutaneous tissue overlying the right greater trochanter (arrow) on coronal PET (D), also seen on axial fused PET-CT (C), compatible with a pressure ulcer.

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Fig. 22: 71 year old female with intense lower back pain. Sagital reconstruction CT (A) and fused PET-CT (B) images show lytic lesions with intense uptake. Biopsy confirmed spondylodiscitis caused by multiresistant mycobacterium avium.

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**Fig. 23:** 46 year old male in treatment for malignant melanoma. On CT (A) we can appreciate the mesenteric fat stranding and a few enlarged lymph nodes, with subtle uptake on fused PET-CT (B), compatible with mesenteric panniculitis.

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Fig. 24: 23 year old HIV positive male patient who was studied for fever of unknown origin, show abundant enlarged inguinal lymph nodes (arrows) on coronal reconstruction of an enhanced CT (A), with increased activity on PET (B) as well as enlarged lymph nodes localized in both axillas.

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Conclusion

PET-CT limitations have been well documented, nonetheless, there are more benefits than disadvantages, as long as all possible pitfalls, artifacts and benign entities are considered during its interpretation.
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