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Incidental Nuclear Cardiology findings in the interpretation of Myocardial SPECT Imaging

Razi Muzaffar, DO[1]; Osama Raslan, MD[1]; Fatma Ahmed, MD[1]; Leonard Goldfarb, MD[2]; Barbara Sterkel, MD[2]; Medhat M. Osman, MD, ScM, PhD[1,2]

[1] Radiology, Div of Nuclear Medicine, St Louis University, 3635 Vista Avenue, Saint Louis, Missouri, 63110

[2] Radiology, Div of Nuclear Medicine, John Cochran VA Medical Center, St. Louis, MO

Corresponding Author:

Medhat M. Osman, MD, MS, PhD

Saint Louis University

Department of Radiology/Division of Nuclear Medicine

3635 Vista Ave, 2-DT

St. Louis, MO 63110

Telephone: 314-577-8047

Fax: 314-268-5144

Email: mosman@slu.edu

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Abstract

Myocardial SPECT imaging plays a crucial role in the diagnosis of coronary artery disease providing a non-invasive tool to monitor ischemia and infarction. The findings can have a profound impact in diagnosing and managing these patients. However, non-cardiac incidental findings on myocardial SPECT images can also impact the management of these patients. These non-cardiac subtleties are most often detected on the raw rotating images which are often overlooked. The intent of this pictorial essay is to illustrate several subtle non-cardiac abnormalities within nuclear cardiac imaging which can have an impact on patient management and follow-up.

Introduction

The overall leading cause of death in the United States continues to be coronary artery disease (CAD) with an excess of $400 billion spent on cardiovascular disease alone [1]. As the life expectancy of the population continues to increase the risks of heart disease at some point in a person's lifetime increases as well. Myocardial perfusion imaging (MPI) using single photon emission computed tomography (SPECT) continues to be an important non-invasive tool for clinicians to evaluate suspected or known CAD [2]. However, in addition to the cardiac findings, incidental findings can also be seen on the rotating raw SPECT images and/or the CT used for attenuation correction when utilized [3]. These findings may lead to an early diagnosis requiring further treatment [4]. Therefore, careful evaluation of both cardiac and non-cardiac findings needs to be performed. In this article we will demonstrate various non-cardiac findings detected on MPI with SPECT/CT. To the best of our knowledge, this may be the first article to compile these various abnormalities in a single paper.

Methods

A log recorded cases of incidental non-cardiac abnormalities. All cases and images were reviewed along with supporting images from other modalities when available. The most interesting images were selected for this review.

Chest abnormalities

MPI is primarily used to evaluate myocardial perfusion, however, significant information can be attained from the rotating raw images of both the heart and the surrounding structures. For example, subtle changes surrounding the heart such as a small pleural effusion can be visualized with MPI (Fig.1). On the other hand, fetal dextrocardia is a rare condition typically found incidentally with various congenital abnormalities with an incidence less than 1% (Fig.2) [5].

In close proximity to the heart is the lungs which can have various abnormalities present on MPI. For example, COPD is a debilitating disease related to nearly 3 million deaths in 2015 [6]. Although subtle, COPD is recognizable on the rotating raw MPI images as flattening of the diaphragm (Fig. 3). Pleural effusions are often seen in conjunction with a variety of pathologies and can be seen as an area of reduced counts on MPI (Fig. 4). This pattern of photopenia can also be seen in patients having undergone a pnuemonectomy (Fig.5).

One of the more common and well known incidental findings on MPI has been lung cancer which is the leading cause of cancer death world-wide among both men and women [7]. However, neuroendocrine tumors are rare tumors that can occur within any tissue including the lung (Fig.6). Pulmonary carcinoid tumors are the second most common neuroendocrine tumor but only comprise 1-2% of all lung tumors [8]. In addition to lung cancers, tumors of the mediastinum such as a thymoma can be seen on MPI (Fig.7). Thymomas can be benign or malignant and account for nearly 20% of anterior mediastinal neoplasms in adults [9].

Incidental areas of uptake have also been documented in the breasts and commonly due to malignancy (Fig. 8) [10-11]. However, non-malignant causes of uptake have also been seen to cause radiotracer accumulation in the breasts. For example, gynecomastia in males is commonly encountered due to various causes. It is due to benign proliferation of glandular tissue in the breast but is often a precursor of an underlying disease (Fig. 9) [12-13]. Furthermore, areas of infection within the breast have also been found to demonstrate focal radiotracer accumulation (Fig. 10).

GI Abnormalities

A common hurdle in the interpretation of MPI is the presence increased liver, bowel or gastric activity predominantly affecting the inferior wall. The drawback of all technetium-99m labeled myocardial perfusion agents is the clearance by the liver and excretion by the biliary system into the duodenum [14]. One such example of abnormal activity this can cause is with gastric reflux with subsequent progression into hiatal hernias which can mimic lung cancer on the raw MPI and cause chest pain (Fig 11-13). A variety of techniques have been performed to reduce this uptake with varying degrees of success [15]. Although this is commonly encountered during the rest portion of the exam, it is becoming more common during the stress portion as well due to the increased use of pharmacologic stress rather than treadmill stress (Fig. 14).

Multiple abnormalities in the liver can cause altered radiotracer distribution on MPI. Non-Alcoholic fatty liver disease affects 25-30% of the population and can lead to cardiovascular diseases, cirrhosis or hepatocellular cancer [16]. The effects of fatty liver can be seen on MPI as an area of photopenia within the liver (Fig. 15). In addition, a common complication of cirrhosis is ascites which can also be seen with MPI (Fig. 16). The progression of liver disease to liver failure and potential liver transplant requires cardiac clearance. The prevalence of CAD in patients requiring a liver transplant ranges from 7.1-28%. As part of the cardiac work-up, MPI is often used in conjunction with other screening measures [17]. Other causes of photopenia in the abdomen on MPI have been described in the literature such as simple hepatic cysts (Fig. 17), echinococcal cysts, cholecystitis [18]. Various tumors in the abdomen have also been shown to cause photopenia in the abdomen (Fig. 18).

Incidental CT abnormalities

With the advancement of technology and increased availability of SPECT/CT, many facilities perform the MPI study with CT attenuation correction to improve the diagnostic accuracy of the exam. This additional layer of imaging allows for the detection of innumerable findings, both benign and malignant, not apparent on the MPI itself (Figs 19-21) [19]. A recent study demonstrated nearly 70% of all MPI studies have both minor and major extracardiac findings on the attenuation correction CT. Of the major extracardiac findings, more than half (52.6%) were unknown [20]. This study emphasizes the value of reviewing the CT portion of the exam and sheds light on the amount of information available in one of the most common nuclear medicine study performed.

Conclusion

MPI with SPECT or SPECT/CT is a valuable tool in evaluating suspected or known CAD but can also detect and diagnose a variety of pathologies. Whether the findings are apparent or subtle, they can have a profound impact on patient management and appropriate follow up. The detection and reporting of these subtle abnormalities often requires careful inspection of both the raw projection images and the CT performed for attenuation correction. Therefore, interpretation of myocardial perfusion imaging should be limited to merely the evaluation of the heart.

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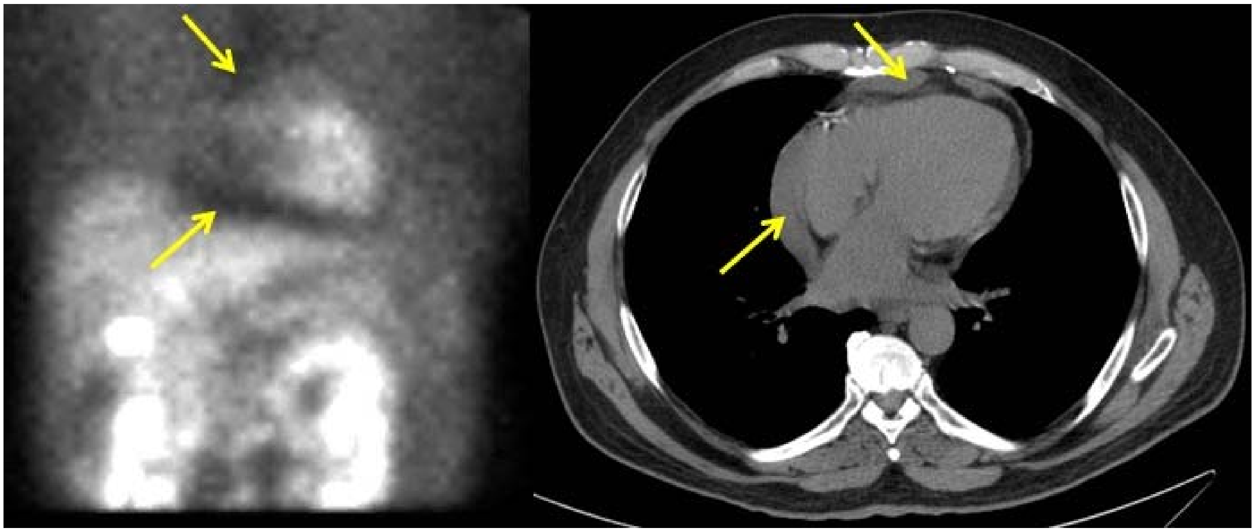
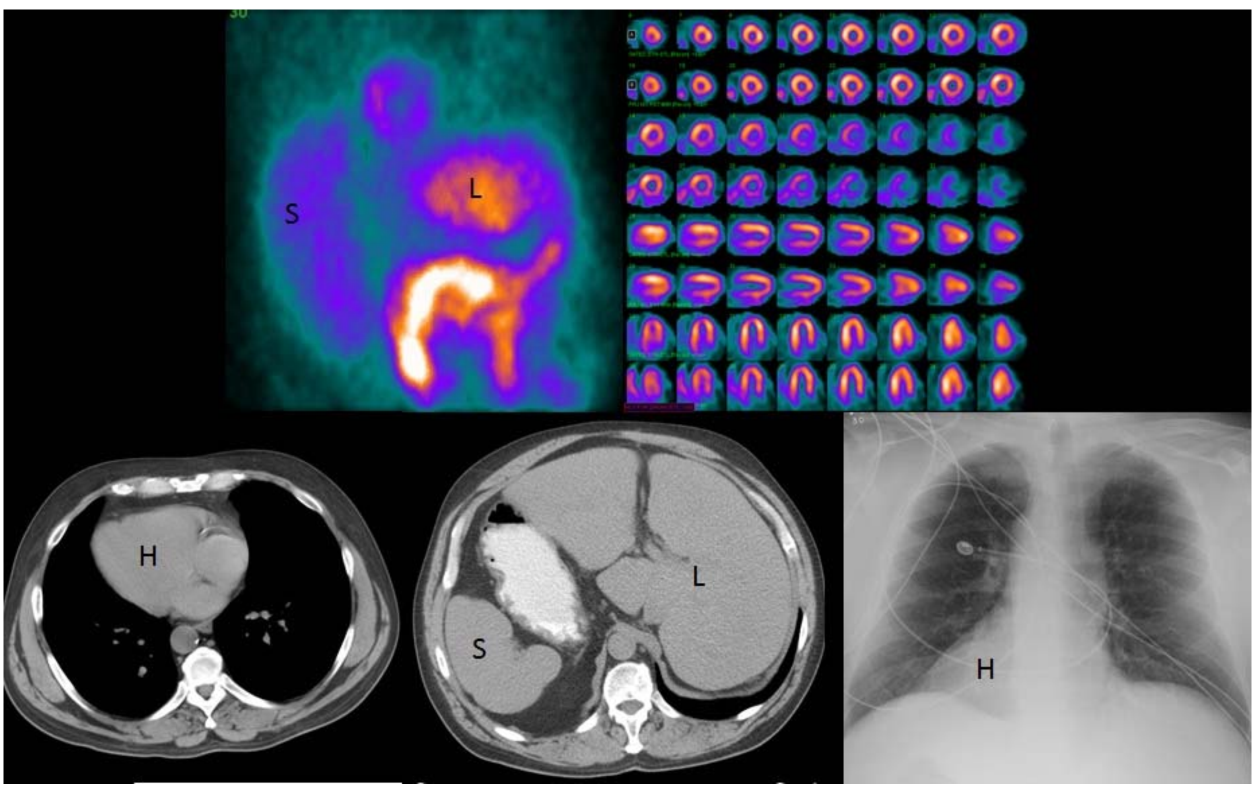
Figures

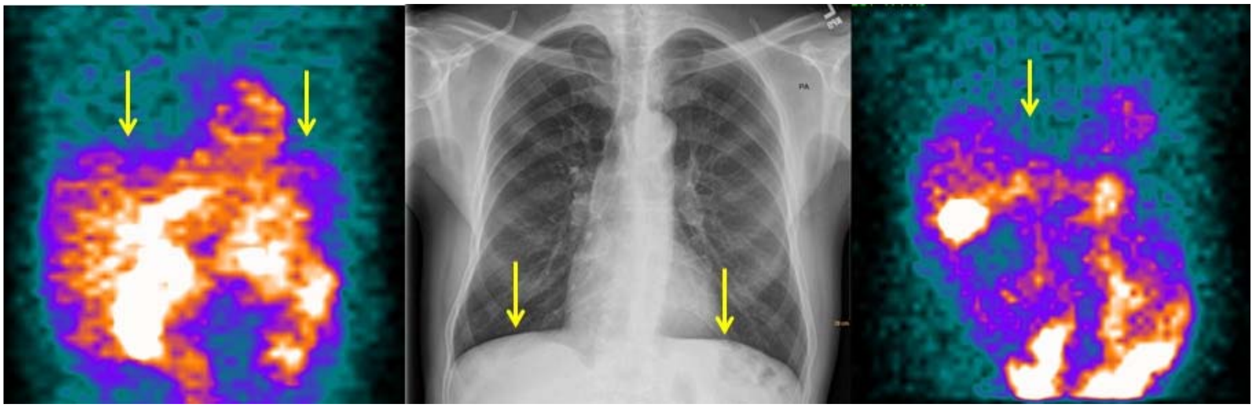


1) Patient presenting with chest pain and shortness of breath. The raw image (left) shows a small area of photopenia surrounding the heart (arrows). Cross section CT (right) demonstrates a small pericardial effusion (arrows).

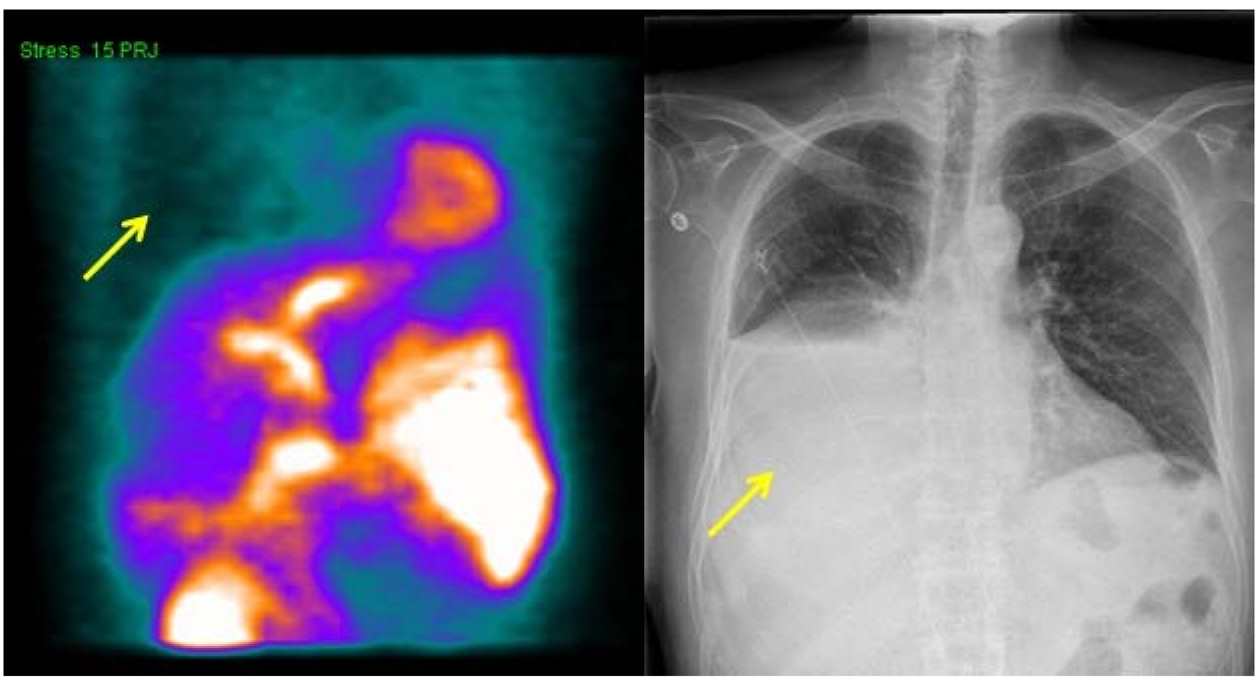


2) Patient with situs inversus presenting with chest pain. The raw image (top left) demonstrates an enlarged spleen (S) in the right abdomen and liver in the left abdomen (L). The processed images (top right) show the lateral wall and septum flipped from the

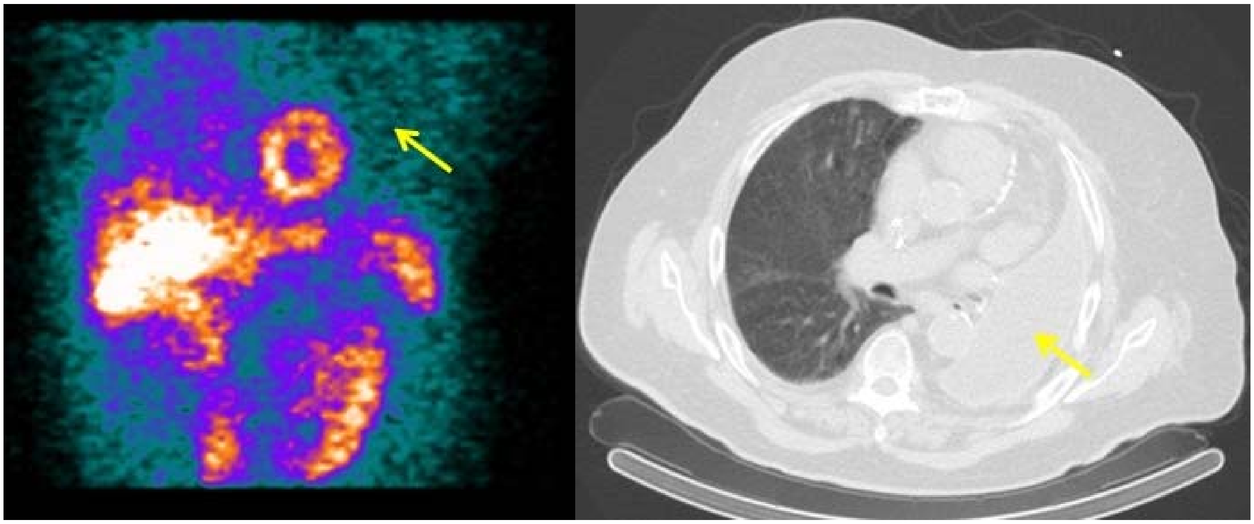
normal position evidenced by a short septum most prominent in the horizontal long axis (bottom rows). CT and X-ray (bottom row) demonstrate the heart and major organs are reversed or mirrored from their normal positions.



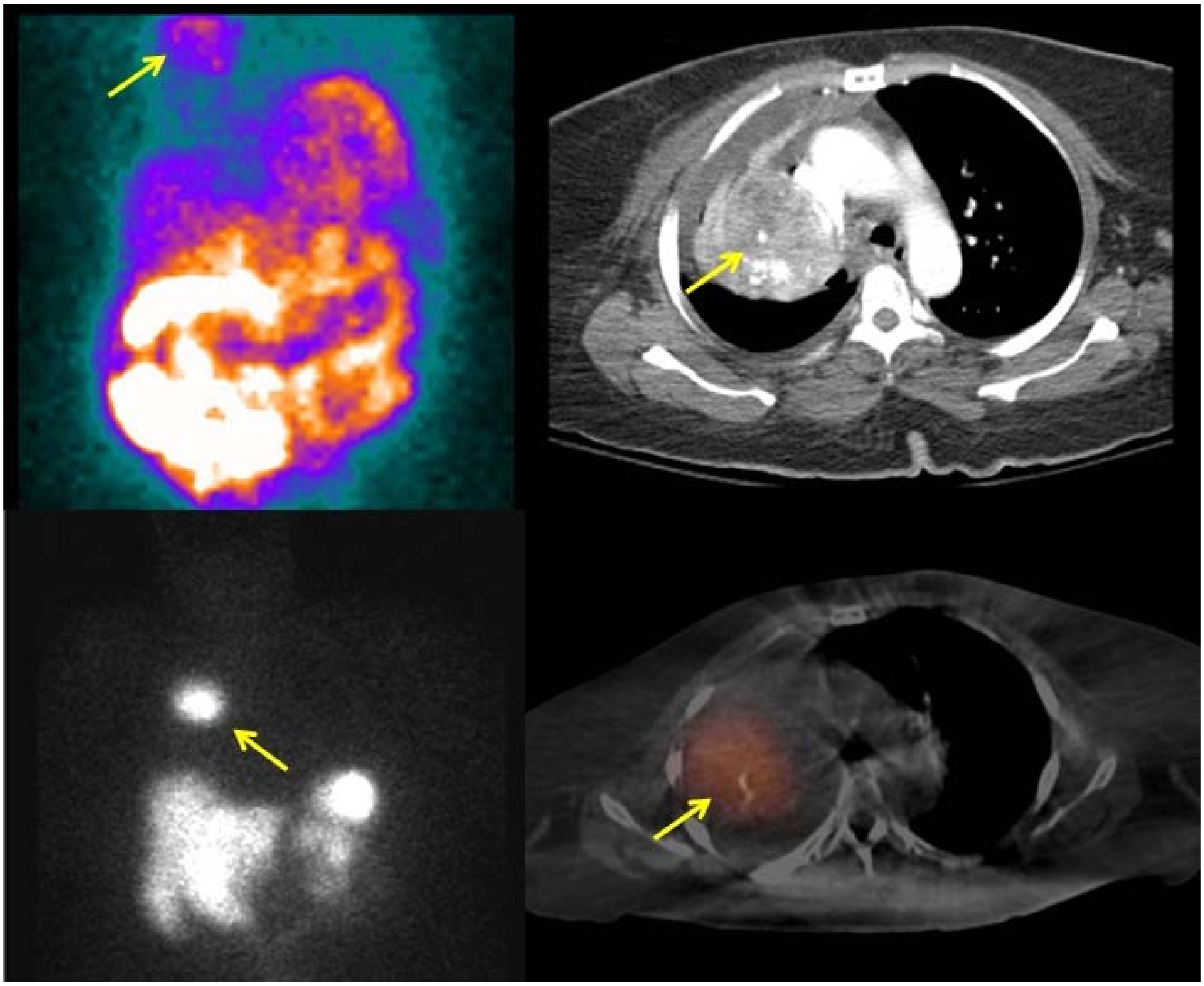
3) Patient with COPD presenting with flattening of the diaphragm (arrows) seen on the raw stress (left) and rest (right) images as well as X-ray (center).



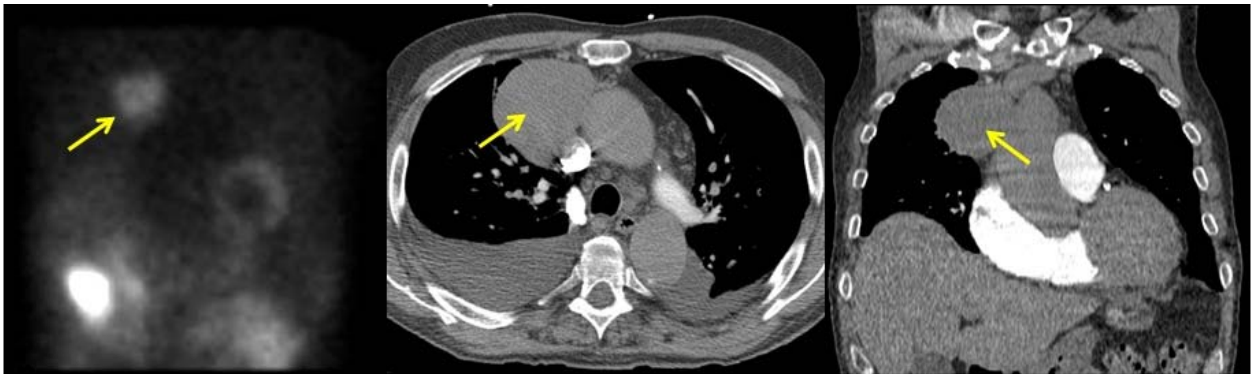
4) Relative photopenia in the right chest cavity seen on the raw image (left) and chest X-ray (right) correlating with large pleural effusion (arrows).



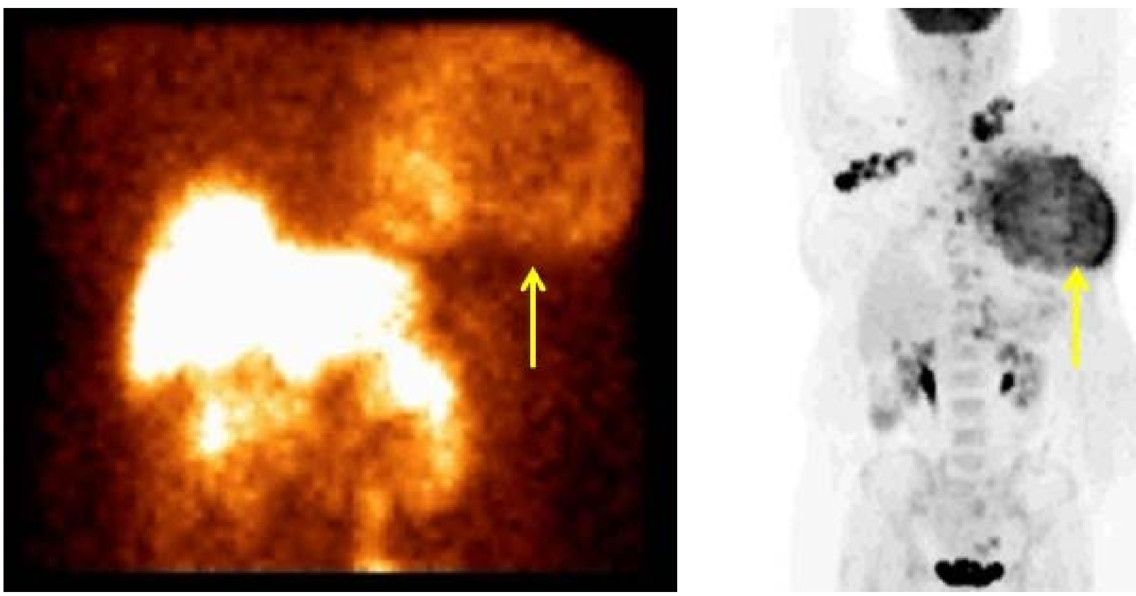
5) Patient with a history of left lung cancer status post left pneumonectomy. The raw image (left) shows reduced counts in the left chest (arrow) correlating with pneumonectomy changes as seen on CT (right).



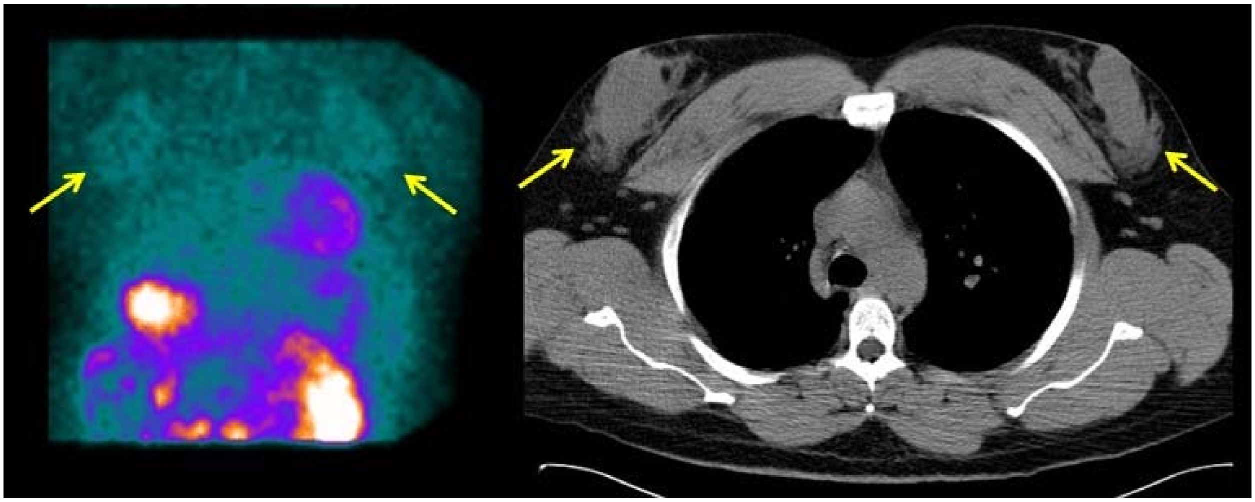
6) Patient with a history of carcinoid tumor presenting with chest pain. The raw image (top left) shows a right upper chest mass (arrows). Contrast enhanced CT (top right) demonstrated a heterogeneous enhancing mass in the right lung. Octreoscan with SPECT/CT was performed demonstrating a mass in the right chest on planar image (bottom left) which fuses with the right lung mass on SPECT/CT (bottom right).



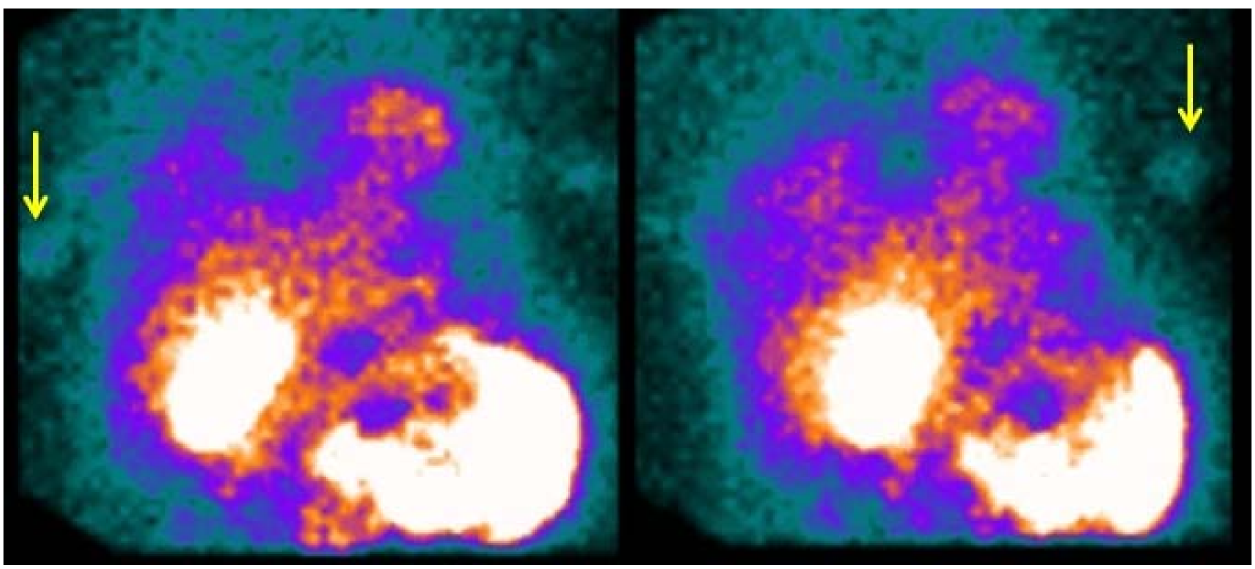
7) Patient presenting with chest pain. The raw image (left) shows a round area of increased uptake in the right upper chest (arrow). Axial (center) and coronal (right) CT images demonstrate a mass in the right mediastinum which was biopsied and found to be a thymoma.



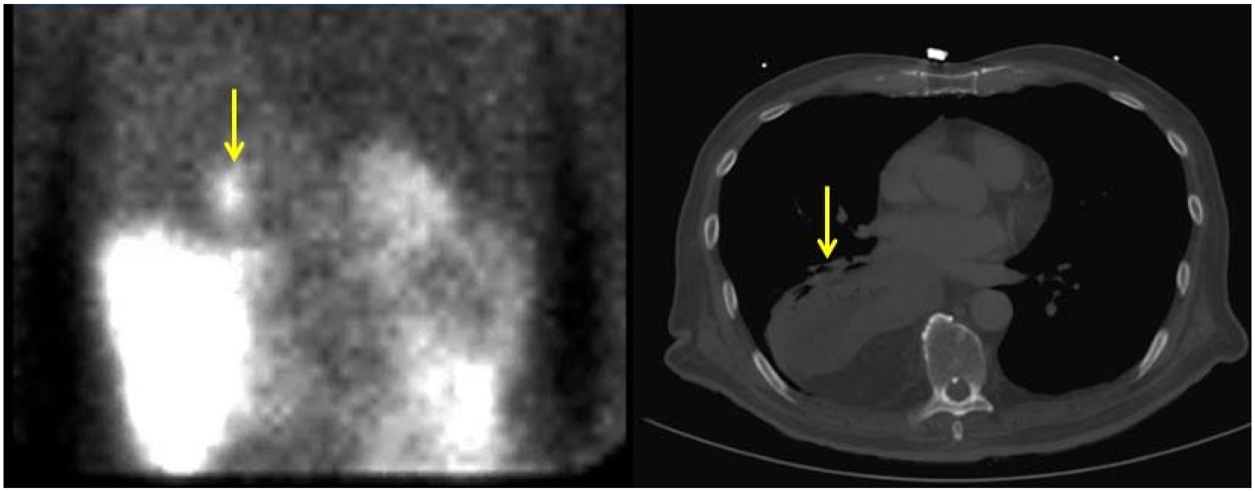
8) Female patient with recently diagnosed breast cancer presenting for pre-operative risk assessment. The raw image (left) shows a large mass in the left breast (arrow). PET/CT was performed and the maximum intensity projection image (right) demonstrates the large left breast mass (arrow) with multiple small metastatic lymph nodes.



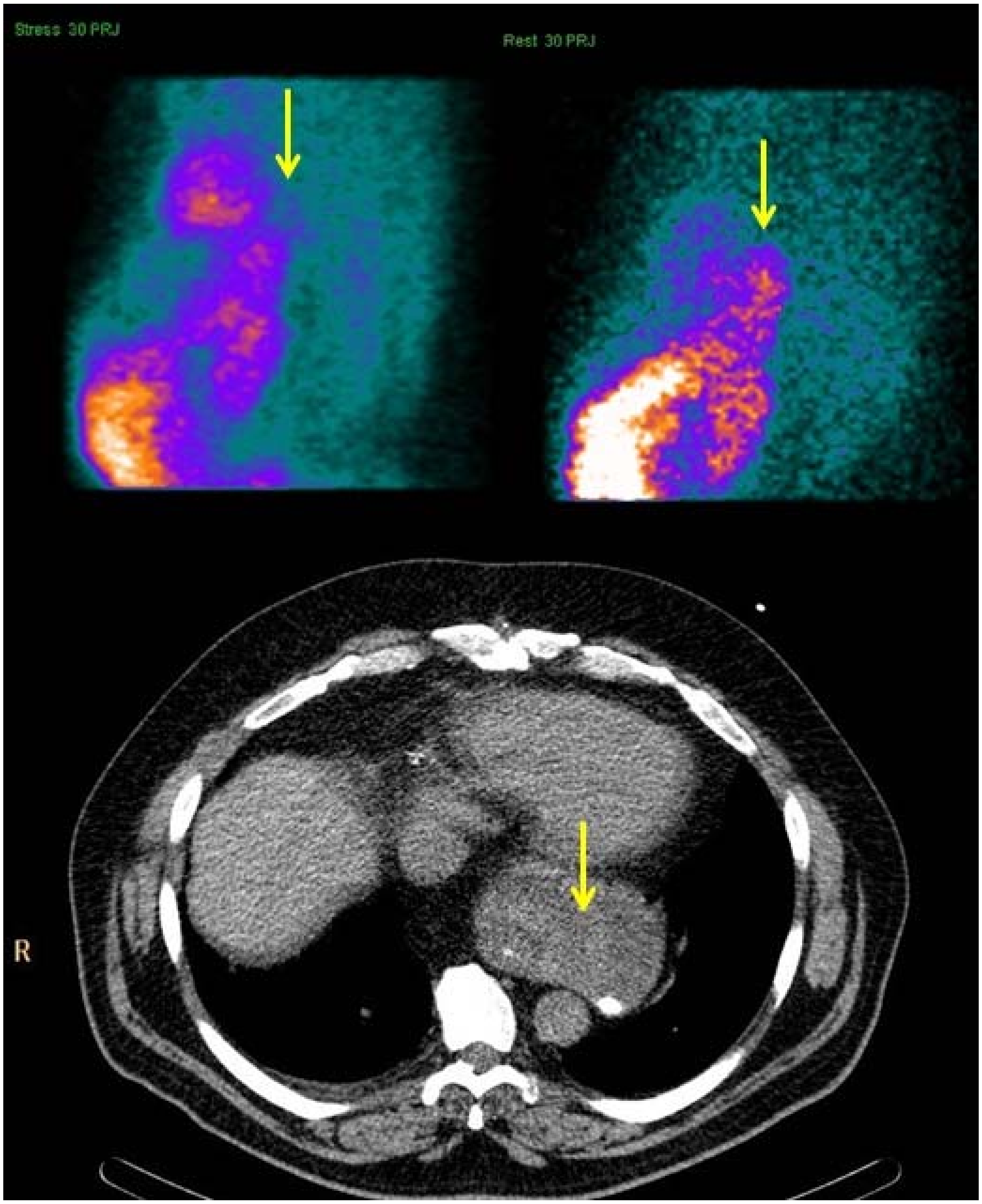
9) Male patient with a history of end-stage liver disease presenting for liver transplant evaluation. The raw image (left) shows round areas of mild increased uptake in the chest (arrows) correlating with gynecomastia changes on CT (right).



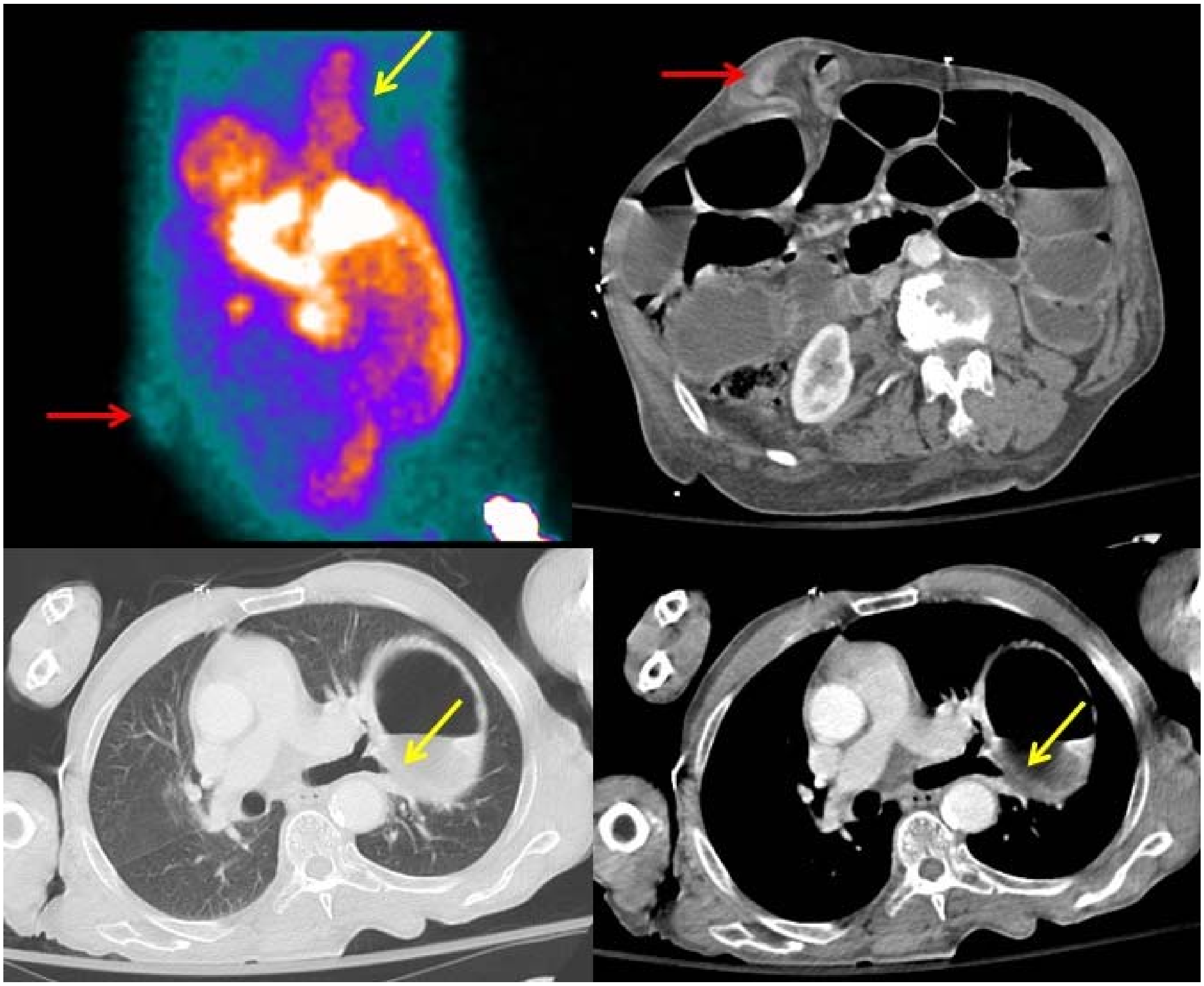
10) Female patient presenting with chest pain. The raw images demonstrate small areas of increased uptake bilaterally in the chest (arrows). Clinical exam demonstrated abscesses in the bilateral lower breasts.



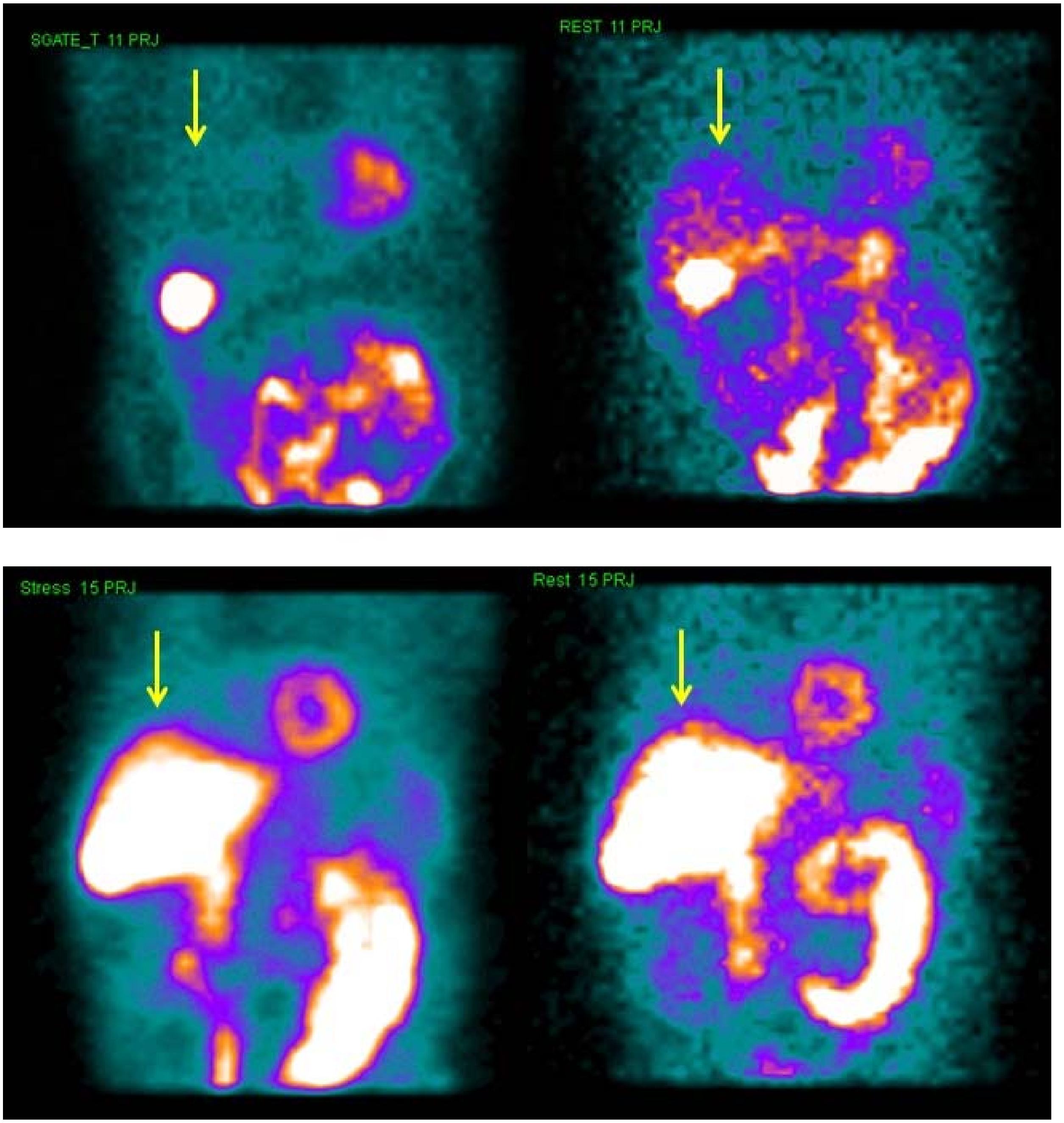
11) Patient presenting with chest pain. Raw image (left) demonstrates abnormal tracer accumulation in the right chest (arrow). CT (right) demonstrates a large diaphragmatic hernia in the posterior right hemidiaphragm containing nearly all of the stomach.



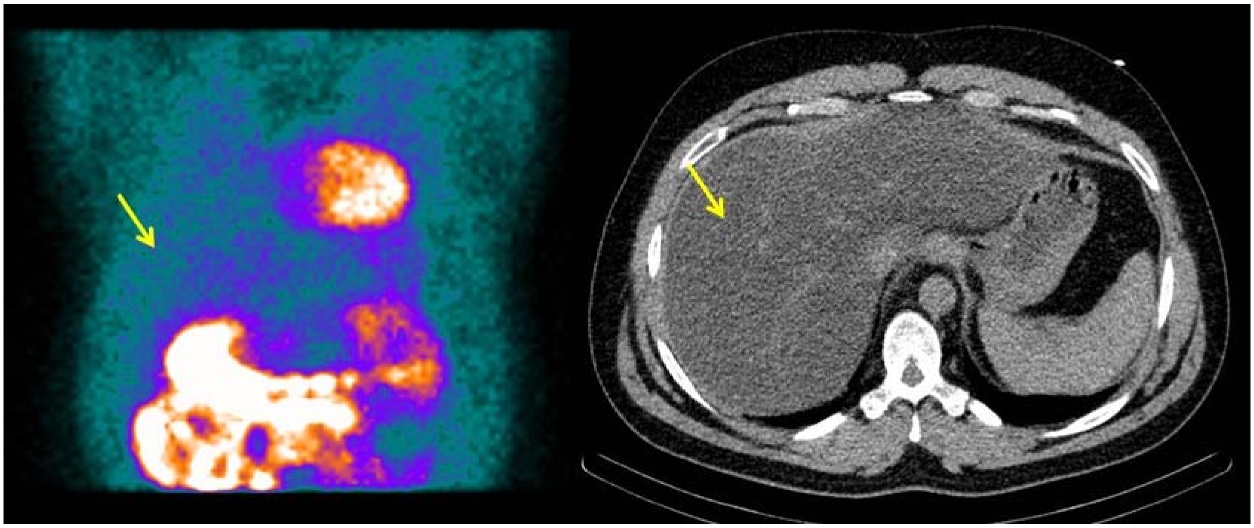
12) Patient presenting with abnormal tracer accumulation posterior to the heart seen more pronounced at rest than stress (arrow). CT (bottom) demonstrates a moderate hiatal hernia (arrow).



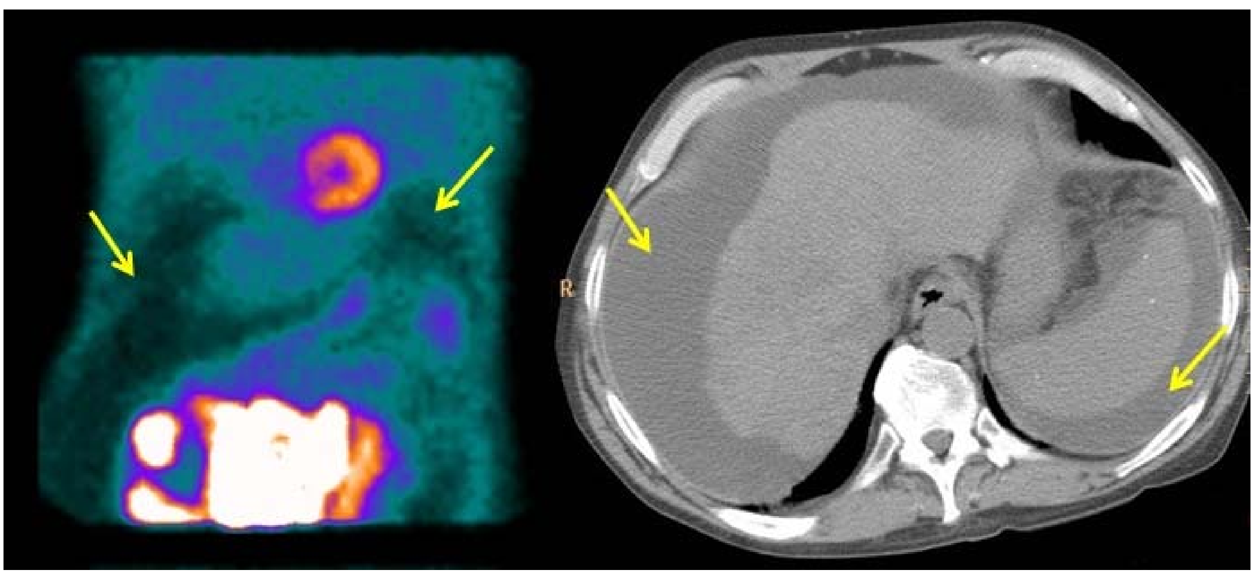
13) Patient presenting with chest pain. Raw MPI (top left) demonstrates a focus of uptake in the anterior abdominal wall (red arrow) and linear uptake in the chest. CT (top right) demonstrates a ventral hernia (red arrow) as well as a large hiatal hernia (yellow arrows, bottom row).



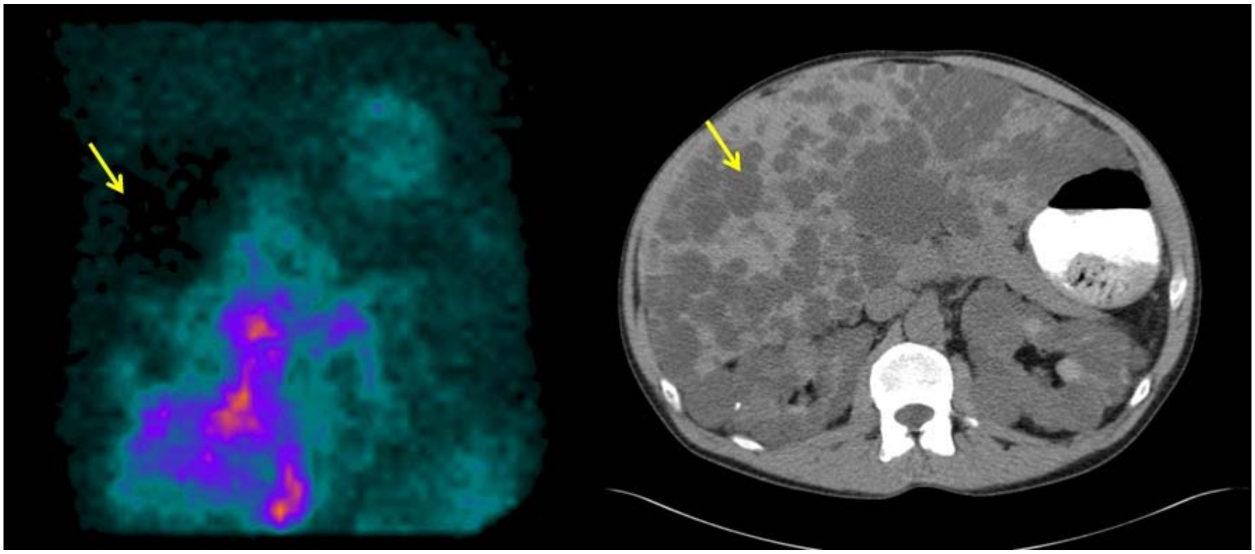
14) Treadmill vs. Pharmacologic. The top row depicts a patient undergoing a treadmill stress test which demonstrates minimal liver (arrows) and more distal bowel activity compared with the rest. The bottom row depicts a patient undergoing a pharmacologic study with intense liver and bowel activity at both stress and rest.



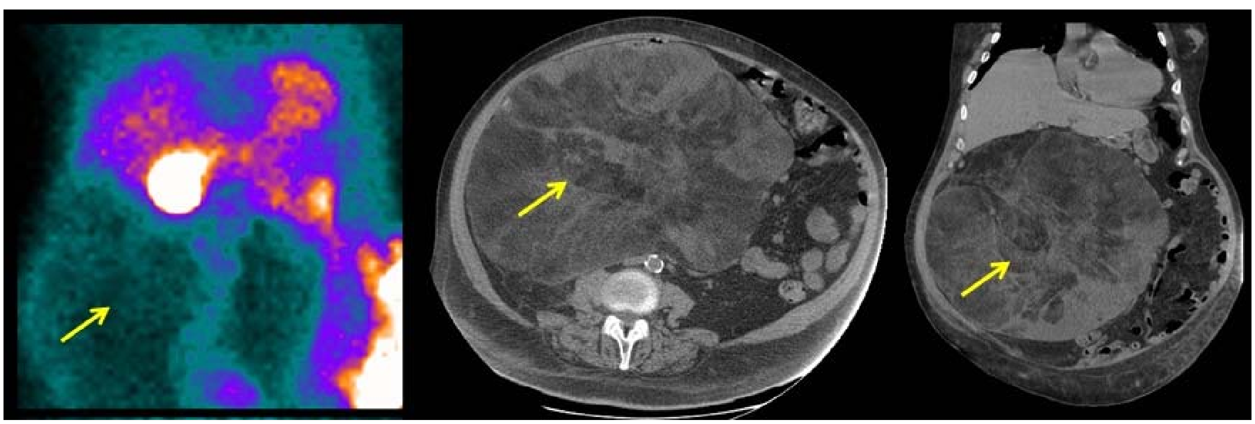
15) Raw MPI (left) demonstrates minimal uptake in the liver (arrow). CT (right) demonstrates diffuse fatty changes throughout the liver (arrow).



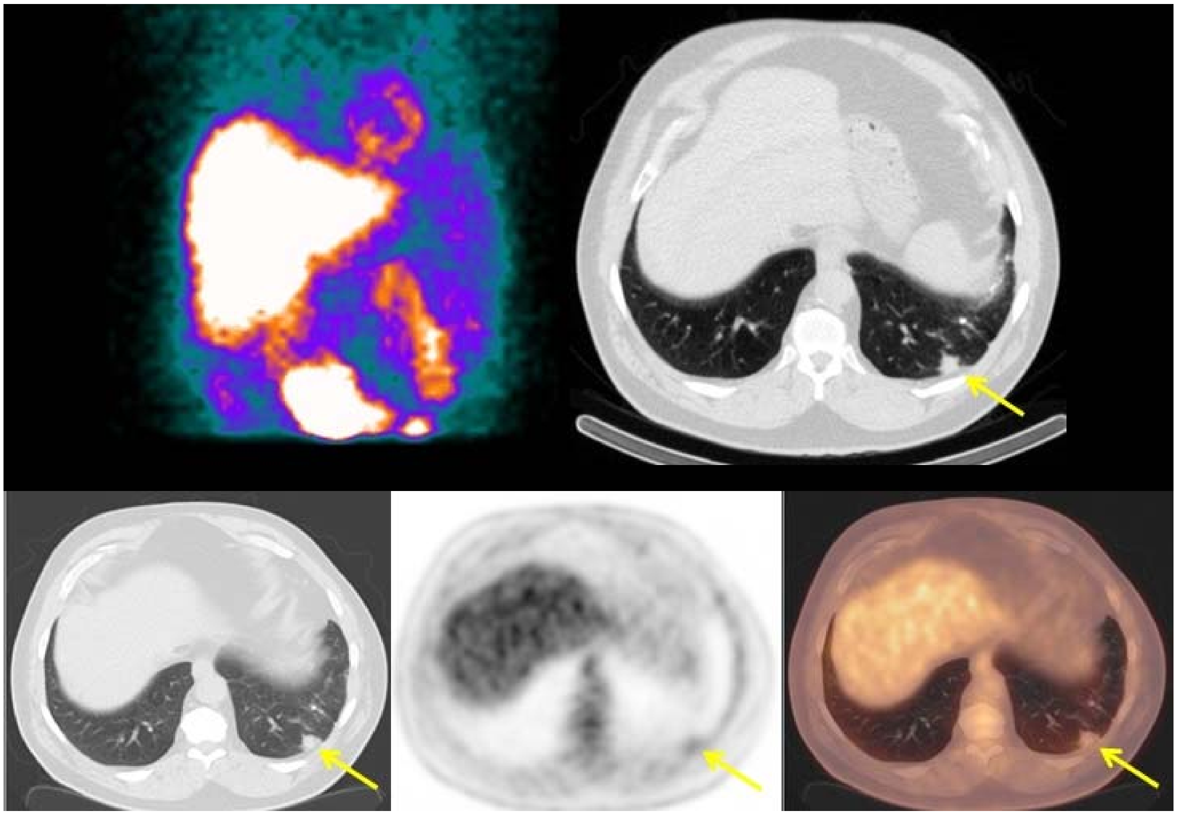
16) Patient with end-stage liver disease presenting for liver transplant evaluation. Raw MPI (left) demonstrates areas of photopenia throughout the abdomen (arrows). CT (right) demonstrates diffuse ascites surrounding the liver and spleen.



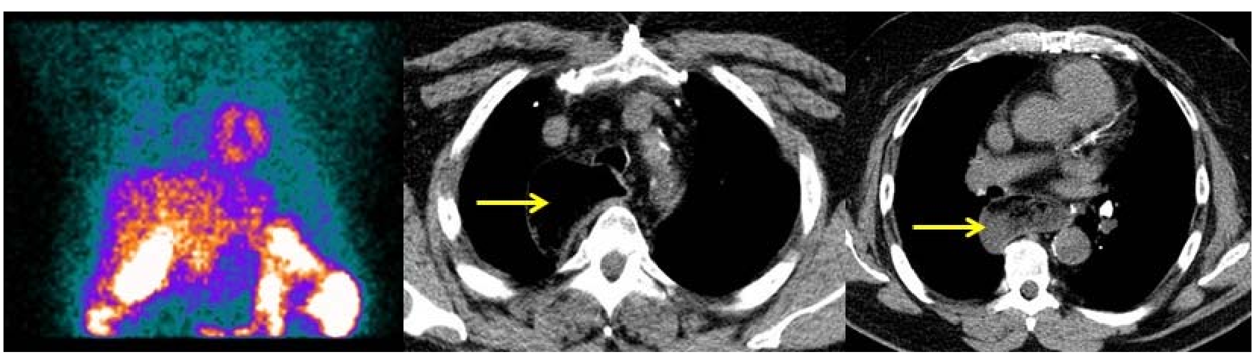
17) Patient with end-stage renal disease presenting for preoperative evaluation. Raw MPI (left) demonstrates relative photopenia in the liver (arrow). CT (right) demonstrates polycystic hepatic (arrow) and renal disease.



18) Patient presenting for preoperative evaluation. Raw MPI (left) demonstrates a large area of photopenia within the abdomen. CT images (middle and right) demonstrate a large intra-abdominal fatty mass which was biopsy proven well-differentiated liposarcoma.



19) Patient presenting with chest pain. Raw MPI was unremarkable (top left). CT performed for attenuation correction (top right) demonstrates a subcentimeter spiculated nodule in the left lung base (arrow). PET/CT was performed (bottom row) showing mild FDG uptake in the nodule (arrow) with SUV max 2.5. Biopsy was performed and consistent with adenocarcinoma.



20) Patient presenting with chest pain. Raw MPI images (left) are unremarkable. CT performed for attenuation correction (middle and right) demonstrates significant esophageal dilation (arrows) consistent with the history of achalasia.

21) Various other subtle abnormalities are often seen on the CT performed for attenuation correction. A small haemangioma is seen in the body of T12 (yellow arrow). A subcentimeter exophytic isodensity in the right kidney is seen (red arrow). A small left adrenal adenoma is seen (green arrow).