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Clinically Significant Incidental Findings on the Unenhanced CT Portion of PET/CT Studies: the Indian Experience

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Abstract

Background: The unenhanced CT part of a PET/CT examination is undoubtedly useful for anatomical localization and attenuation correction. Our study was undertaken with the objective of evaluating the incidental findings from the unenhanced CT portion of PET/CT studies through independent interpretation by an expert CT radiologist and to assess their clinical significance.

Methods: Standard PET/CT image acquisition protocol was used on a total of 300 patients. The unenhanced CT studies were read without prior knowledge of findings from PET and PET/CT fused images, independently by an experienced radiologist. All recorded findings were classified as being of major, moderate, or minor significance, corresponding to definitions previously used in similar studies.

Results: Unenhanced CT revealed potentially clinically significant incidental findings in 11 patients, findings of moderate clinical importance in 15 patients and those of minor clinical importance in 214 patients. The first group largely included patients with neoplastic processes (both metastatic and synchronous primary) which were not detected solely on the PET images. There was a high proportion of tuberculosis (both active and healed) in the latter two groups.

Conclusions: Incidental CT findings are commonly encountered in the course of a PET/CT examination. A small but significant proportion of cases have findings of major clinical significance, which may be detected only based on careful analysis of the CT component. Also, there is a high incidence of tuberculosis (both active and healed) in the Indian setting, which would have important clinical implications. Thus, skilled interpretation of the complete evaluation.

Keywords: Incidental findings; Unenhanced CT; PET/CT

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Introduction

PET scan, or Positron Emission Tomography, is a powerful tool which has made a significant impact in the field of oncology, cardiology, neurology and imaging of inflammatory disorders. To put it very simply, it has the ability to detect sites of high metabolic activity. Since many cancers have significantly higher metabolism than normal tissues or noncancerous masses, PET allows sensitive detection of even small cancers. 18F-FDG PET enables diagnosis, staging, and restaging of many cancers with accuracies ranging from 80% to 90% and is often more accurate than anatomic imaging [1]. FDG PET is a strictly functional modality and lacks anatomic landmarks for precise morphologic orientation. However, the lack of anatomic landmarks and limited spatial resolution of PET can make precise anatomic localization challenging, thus limiting accurate evaluation of cancer patients.

PET-CT Fusion is a newer refinement of the technique that allows the most accurate correlation of anatomic information (from the CT) and metabolic information (from the PET scan).A dual-purpose imaging device, PET/CT is literally the combination of PET (positron emission tomography) and CT (computed tomography) imaging techniques within a single machine. The individual scans, which are taken virtually simultaneously, can be presented separately or as a single, overlapping, or "fused" image. This fused image provides a more reliable and much more effective alternative to the traditional side-by-side visual comparison of PET and CT images. The use of PET/CT has been advocated as a first-line imaging modality for whole-body tumor staging and restaging

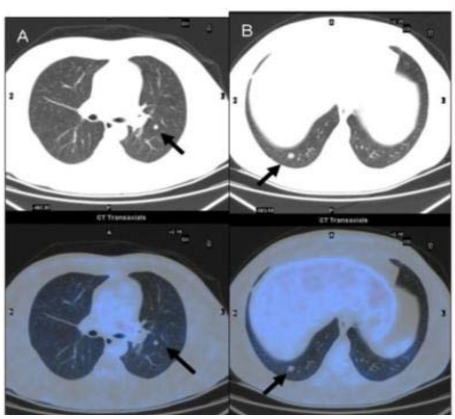

Figure 1: Follow-up case of colon carcinoma showing subpleural nodules on CT (upper row) in left (A) and right (B) lung fields, with no evidence of FDG uptake on the fused PET/CT image (lower row).

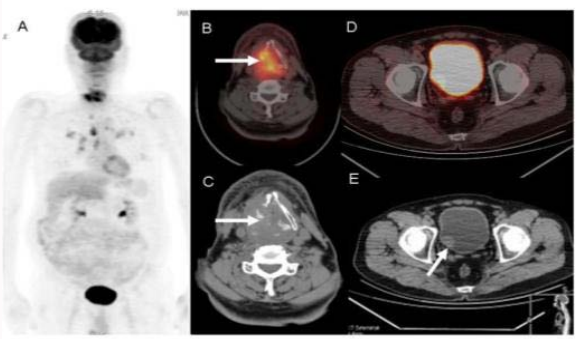

Figure 2: A case of laryngeal carcinoma. MIP image (A) shows increased uptake at the primary site with intrathoracic spread. The FDG avid invasive laryngeal mass is well seen on the PET/ CT and CT image (B,C). Additionally, an unsuspected bladder mass is seen on the CT image (E), which gets obscured on the PET/CT image by the physiological high uptake in the bladder (D).

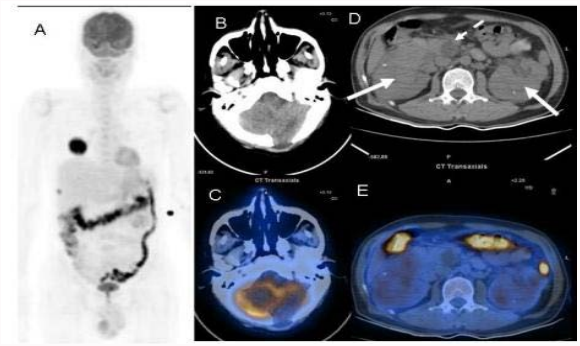

Figure 3: A follow-up case of cerebellar hemangioblastoma. MIP image (A) shows FDG avid metastatic foci in the lung and liver. Axial CT (B) shows a post-operative defect in the left cerebellar hemisphere with reduced adiotracer uptake on the PET/CT image (C). Unsuspected bilateral renal masses (arrows) and pancreatic cysts (dotted arrows) seen on CT (D), none of which show increased radiotracer activity on the PET/CT fusion image (E). This unusual constellation of findings points towards the rare von Hippel Lindau syndrome.

and for assessing response to therapy in different types of cancer [2].

However, although rapid attenuation correction and precise anatomic localization are clearly useful, the value of the independent CT interpretation is not clear, especially because many CT scans obtained as part of PET/CT are obtained at somewhat lower power settings than are standard CT scans and with no or limited use of contrast material. Currently, the CT portion of PET/CT in many centers is a lowered-dose, unenhanced study and used only for image fusion and attenuation correction. Potentially useful information can be added through independent readings of the unenhanced-CT portion of PET/CT by a radiologist skilled in CT. Our study was undertaken with the objective of evaluating the incidental findings from the unenhanced CT portion of PET/CT studies through independent interpretation by an expert CT radiologist and to assess their clinical significance.

Methods

The study included a total of 300 sequential patients (139 men and 161 women; mean age, 52.3 y) referred for clinical evaluation of known or suspected cancer. The institutional review board approved of this prospective study. All subjects fasted for six hours prior to the study. They were administered 10mCi (370 mBq) 18F-FDG intravenously followed by a period of rest of 60 minutes with minimal body activity. The PET/CT scans were performed using a whole body Full Ring PET camera (Discovery STE16-GE). Whole-body CT scanning was performed by a continuous spiral technique using a 16-slice helical CT with a gantry rotation speed of 0.8 second. No intravenous or oral contrast agent was used. After the CT scan, an emission scan was performed from the head to thigh for 2 minutes per frame. The attenuation-corrected PET images using the CT data were reconstructed by using an ordered subset expectation maximization algorithm (20 subsets, 4 iterations),and they were displayed in a 128 x 128 matrix. Accurate co registration of the separate CT and PET scan data was performed. Images were evaluated by an experienced nuclear medicine physician.

The unenhanced CT studies were read on an ADW (Advantage Window) workstation without prior knowledge of findings from PET and PET/CT fused images, independently by an experienced radiologist. Details were recorded concerning the nature of the abnormality, the anatomic location, and any information from previous and subsequent imaging studies. Findings from unenhanced CT were considered significant if they were not detected or explained by PET findings and were considered to clearly require additional work-up. All recorded findings were classified as being of major, moderate, or minor significance, corresponding to definitions previously used in similar studies [3,4]. A finding was considered of major importance when the CT appearance was highly suspicious for an abnormality relevant to the immediate treatment of the patient. Abnormalities were considered of moderate importance when the imaging appearances suggested clinically important disease but required further correlation with other clinical or imaging findings and required eventual medical or surgical treatment. Abnormalities were considered of minor importance when the imaging appearances did not suggest clinically important disease and did not require additional workup.

Results

Unenhanced CT revealed potentially clinically significant incidental findings in 11 patients. Sclerotic metastases were noted in four cases, multiple small subpleural pulmonary metastases in three (Figure 1), cerebral metastasis in one, synchronous malignancy in the bladder (Figure 2) and the kidney in one each. Additionally, one patient had a spectrum of findings pointing toward a rare syndrome

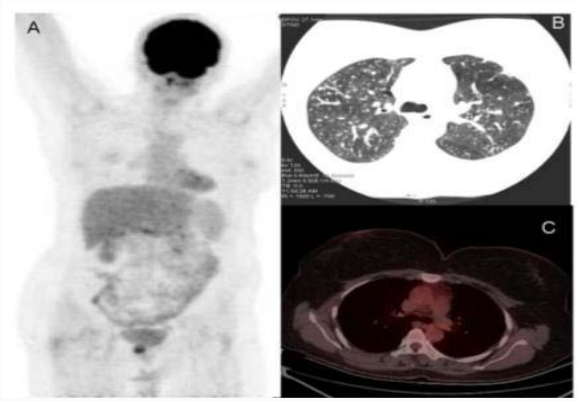

Figure 4: A follow-up case of choriocarcinoma. No residual disease seen on MIP image (A). However CT image (B) shows evidence of military tuberculosis which shows no radiotracer uptake on fused PET/CT image (C).

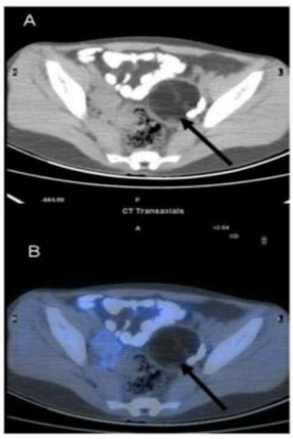

Figure 5: A follow-up case of carcinoma breast. CT image (A) shows a rounded well-defined lesion of fat attenuation suggestive of dermoid cyst. No radiotracer uptake noted on the PET/CT fusion image (B).

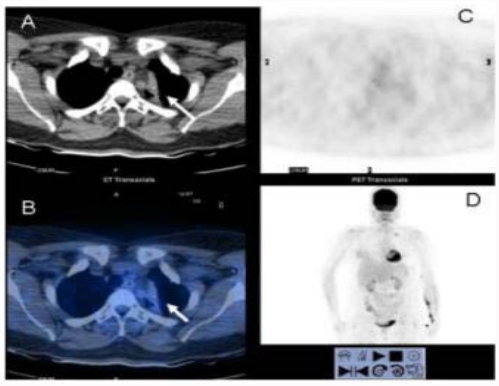

Figure 6: A follow-up case of carcinoma breast. A fibro-calcific lesion is seen in the upper lobe of left lung seen on CT (A). No radiotracer uptake noted on the PET and fused PET/CT images (B, C). MIP image (D) shows evidence of left mastectomy with left supraclavicular lymph-node.

– namely von Hippel Lindau syndrome (Figure 3). None of these findings were detected on PET scans viewed in isolation.

Findings of moderate clinical importance were noted in 15 patients which included pulmonary tuberculosis in 9 patients (Figure 4), calcified left ventricular aneurysm, adrenal adenoma, dermoid cyst (Figure 5), renal Angiomyolipoma, misplaced intrauterine contraceptive device and tubercular cervical lymphadenopathy in one patient each.

There were findings of minor clinical importance in 214 patients which included abnormalities such as gallstones, renal stones, hiatus hernia, abdominal hernia, renal cysts, healed pulmonary Kochs (Figure 6), calcified granulomas in the brain, uterine fibroids, hepatic cysts, prostate enlargement, spondylolisthesis, spondylosis, bone islands, solitary bone cysts, hemangiomas and old post-traumatic changes in bones. Some of these features had already been documented based on previous investigations and did not warrant alteration in management. However, it is important to document these abnormalities as they may explain the symptoms which the patient may develop in the course of follow-up, which is unrelated to the present disease.

Discussion

Clinically significant findings from the unenhanced CT portion of PET/CT are relatively infrequent (3%) but could be serious enough to warrant major alterations in clinical management [5]. Thus, we believe it is most appropriate for the CT portion to be interpreted by a physician skilled in CT interpretation with special attention to the lesions that PET alone can fail to detect.

The importance of potential findings on the CT component of PET/CT is reflected in a recent paper from the American College of Radiology [6] regarding interpretation of PET/CT studies. It is recommended that the interpreting radiologist or nuclear physician report additional findings present on CT images, even if the examination is performed purely for anatomic localization only. There is much debate about who should interpret the studies, but it is clear that the CT component of the study cannot be ignored.

Most of the additional findings detected in our study were classified as being of minor importance, which are extremely common in the general population and do not warrant additional investigation or follow-up. However a noteworthy feature is the large proportion of patients who had features of healed tuberculosis, be it in the lungs, the mediastinum or the brain. This is a finding that is closely related to the high prevalence of tuberculosis in our Indian population. What is worrisome is, that many of these patients are at a risk of developing reactivation owing to the immunosuppression which occurs as an inevitable part of their chemotherapeutic regimens. The relatively large number of patients with active tuberculosis in our study group lends credence to this. Early diagnosis and prompt institution of treatment would lead to early amelioration of symptoms of this completely curable disease. Acute or chronic inflammation, abscesses, inflammatory lymphadenopathy and non-specific reactions following radiotherapy may mimic tumor tissue in PET scans [6-8]. However, analyzing the pattern of disease on the CT component enables distinguishing inflammatory from neoplastic process in the majority of cases. This holds specially true for tuberculosis.

The other important feature is the detection of synchronous malignancy and of distant metastasis which fail to get picked up on PET/CT. The lack of FDG avidity at these sites could be due to several reasons - small size as in the case of pulmonary metastasis, location as in the case of cerebral metastasis and bladder malignancy, and low affinity for the radiopharmaceutical as in the case of mucinous metastasis. It is already known that PET has relatively low sensitivity for cerebral metastatic lesions, mainly because of the limited spatial resolution of PET scanners and the intense metabolic activity already

present throughout the rest of the cortex [9,10]. In certain cases, brain metastases appear as areas of reduced 18F-FDG uptake compared with the surrounding cortex [11]. In addition, it should be recognized that certain tumors with variable 18F-FDG uptake, such as prostate cancer, hepatocellular carcinoma, renal cell carcinoma, bladder carcinoma and osteoblastic bone metastases [12-14], may be more readily detected owing to their abnormal appearance on CT images than owing to their PET appearance.

Conclusions

Incidental CT findings are commonly encountered in the course of a PET/CT examination. Although this may not have a direct bearing on the immediate management in every case, it would have an impact on the overall clinical profile of the patient. A small but significant proportion of cases have findings of major clinical significance, which may be detected only based on careful analysis of the CT component. Also, there is a high incidence of tuberculosis (both active and healed) in the Indian setting, which would have important clinical implications. Thus, skilled interpretation of the unenhanced CT component of the PET/CT scan is a vital pre-requisite to complete evaluation.

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