Discussion

Key words: integrated PET/CT; image fusion; single time–dual modality imaging; thorax; lung lesions

Should integrated PET/CT be used for thoracic lesions?

Why is integrated PET/CT attractive?

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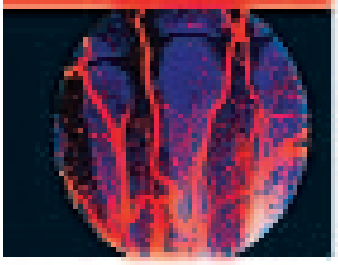

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Abstract

Imaging has emerged to have a central role in oncology based on its use in screening, diagnosis, staging, treatment planning, evaluation of response to treatment, and follow-up. This has created new obligations for both clinical oncologists and imaging experts. Recently, integrated PET/CT was added to the diagnostic methods for evaluation of cancer patients, now typically managed jointly by clinicians from several specialities. There is growing evidence that integrated PET/CT permits improved TNM (tumour, node and metastasis) staging of cancer. Consequently, it is time to summarise its advantages compared to the single modality PET and CT in clinical use. Medical, technical and economic facts support the use of single time–dual modality (integrated) PET/CT rather than dual time–single modality PET and CT imaging of thoracic lesions. There is no reason to deny patients integrated PET/CT. Therefore, the answer to the title question – Should integrated PET/CT be used for thoracic lesions? – is a clear-cut yes!

Introduction

Single time–dual modality whole body imaging such as integrated positron emission tomography (PET) and computed tomography (CT) scanning (PET/CT), is a newly developed investigative method, which has been introduced for the evaluation of cancer. Integrated PET/CT has been studied mostly in patients with lung cancer. Since we do not have the perfect single imaging modality for the assessment of cancer, a two-in-one approach like integrated PET/CT offers increased potential to correctly diagnose the malignant or benign nature of a thoracic lesion, its local extent and relation to surrounding structures, and metastatic spread into lymph nodes and other organs. The ultimate goal would be to foresee cancer with more than 98% certainty. However, no imaging modality can replace histology for securing a cancer diagnosis.

Interpretive Criteria

For a soft tissue lesion which is suspected of representing malignancy, the following criteria in PET imaging are applied: focally increased radiotracer uptake that exceeds normal limits of regional uptake; lesion location in a typical metastatic site and, if necessary, semiquantitative uptake indices. The cut-off criterion for the latter, e.g. indicating separation of malignant from benign disease, is based on institutional validation. Regarding skeletal lesions, the following criteria are applied: intensity of radiotracer uptake (low, medium, high intensity); location of the lesion in the skeleton; and the number of lesions (presence of many lesions indicates malignancy; presence of a few lesions indicates benignancy).

However, some pitfalls remain in PET image interpretation of enhanced focal fluorodeoxyglucose (FDG) uptake. These pitfalls include: injection site and positive lymph nodes proximal to injection site (in the case of paravenous injection); inflammatory soft tissue and skeletal disease; effects of muscle tension (including stress); and tonsillar uptake. Regular thymic uptake in children and young adults, and following chemotherapy in younger patients, has frequently been misinterpreted as a retrosternal recurrence of a mass suspected to be
cancer. Other FDG foci that may be misinterpreted include: laryngeal uptake; unspecific uptake in the wall of hollow organs such as the caecum, bowel and stomach (in order of observation frequency); caliceal and pelvic activity within the kidney; urinary tract activity; ovarian follicles; and fibroid uterus. Nevertheless, most but not all radiopharmaceutical-related causes of misinterpretation are avoidable using integrated PET/CT.

The single time two-in-one assessment with CT enables depiction of the potential primary tumour, its size and extent, mediastinal or chest-wall invasion (contiguity,

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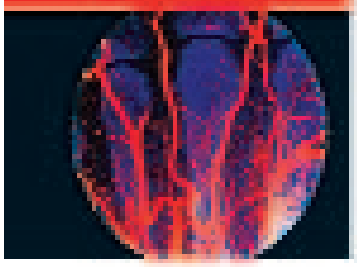


infiltration, rib destruction), size of mediastinal and hilar (including interlobar and lobar) lymph nodes, retrocrural lymph nodes, and double search for metastases of the liver, adrenal glands and skeleton.

Methodological benefits of integrated PET/CT

Results from recent publications indicate that integrated PET/CT imaging is superior compared with (dual-time) CT alone and PET alone, or visual correlation of PET with CT, in determining the stage of disease in non-small cell lung cancer.[1,2] There is evidence for improvements in T-, N- and M-staging. In addition, differentiation between tumour and peritumoral atelectasis was improved.[3] Even integrated PET/CT may not be the perfect method to accurately distinguish contiguity from invasion, but it has been found to be statistically superior compared to other imaging modalities.[2] Moreover, specificity for lymph node staging was found to be improved up to 94%, and delineation between N1 or N2 stage, based on underlying morphology, was similarly improved.[1]

The provision of exact lymph node staging enables a carefully directed reduction in the number of patients unnecessarily undergoing surgery. Furthermore, treatment using pre-operative neoadjuvant chemoradiotherapy,[4] an increasingly established therapeutic method, is also dependent on exact lymph node staging. For this approach, integrated PET/CT backed up by biopsy currently offers the best results for lymph node staging (N0 *vs*. N1 *vs*. N2), thereby enabling decisions on an appropriate treatment option – surgery, neoadjuvant chemoradiotherapy (for down-staging) followed by surgery, or other local and systemic components of therapy.

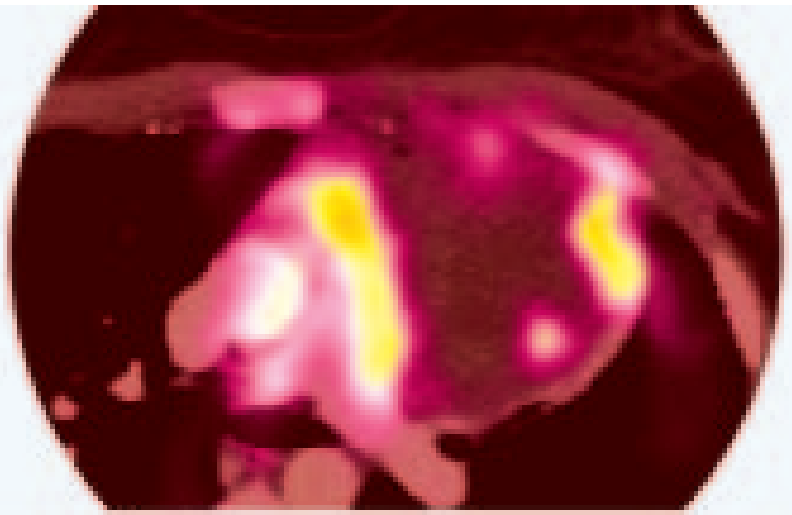
In addition, integrated PET/CT greatly assists in overcoming non-detection or discrepancies in detection of metastatic disease because cancer-associated functional changes, detected by PET, occur much earlier than morphological changes. On the other hand, the better anatomical spatial resolution of CT permits delineation of small cancer lesions missed by PET.

As outlined above, another benefit of integrated PET/CT is the decrease in reporting of false-positive findings based on PET alone (and the inherent follow-up by further diagnostics), which occur because of physiologic uptake of tracer that may mimic metastatic disease.

A further specific advantage of integrated PET/CT in the clinical setting, compared with use of the single modalities, is its preferred application for initial diagnostic staging. Single modality imaging may be sufficient for assessment of response to therapy, or for restaging in the case of cancer recurrence proven by biopsy, when less detailed imaging for disease progression may be required. However, whether this argument remains true is subject to results from further multicentre outcome studies.

Software or hardware image fusion?

Image fusion based on dual-time CT alone and PET alone is tedious and time consuming (requiring attention to deep inspiration, patient positioning, gated acquisition, acquisition in different body configurations). Furthermore, it is also cost-intensive, being limited to a specific series of images of a given part of the body (Figure 1) rather than a routine whole body approach and, consequently, is clinically impractical for routine use. There are other limitations such as incompatibility of various items of digital imaging equipment, lack of communication in medicine standard implementations, inefficient multimodality picture archiving and communication databases, lack of connectivity and compatibility between various divisions/departments, and, not to be forgotten, flexibility in patient scheduling. These limitations are mostly resolved with single-time integrated PET/CT imaging.



Should integrated PET/CT be used for thoracic lesions?

Of course – yes! There are several medical reasons which support the answer "yes". Diagnosis of tumour stage and assessment of tumour response to treatment relies heavily on imaging information. Another argument is that multimodal therapy commonly depends on interspeciality co-operation. In addition, precise definition of tumour target to deliver various forms of local treatment as accurately as possible is becoming increasingly meaningful. Moreover, the patient undergoing PET/CT experiences a reduction in the number of imaging appointments, and the information given by imaging experts in terms of TNM staging is superior to other imaging approaches.[5]

There are also technical reasons to support the use of integrated PET/CT. Lesions, characterised by increased radiotracer uptake, are depicted with superior spatial resolution by CT. Furthermore, because of the use of CT data for photon attenuation correction in combination with newly developed detector materials for PET imaging, the procedure time for whole body imaging is significantly shortened.

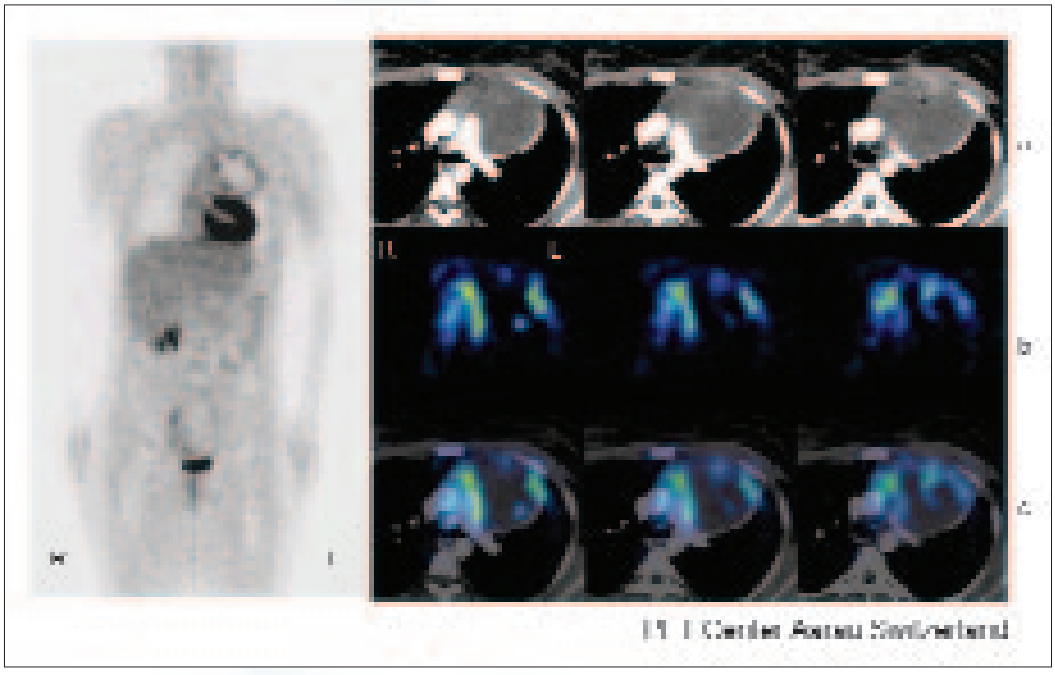


Figure 1. Imaging data from a 24-year-old female presenting with non-Hodgkins lymphoma. Results are from an intravenous contrast enhanced spiral and native CT of the thorax (a) and a dual-time whole body trunk PET (b; for diagnosis of viable residual mediastinal lymphoma mass). Image fusion (c) provides near precise localisation of the still viable, remaining lymphoma tissue following 3 cycles of chemotherapy. Image fusion of thoracic images from these dual modalities took approximately 30 minutes for data manipulation and actual fusion, and ultimately shows a good fusion result in a subset of thoracic images. However, such work flow is of very limited routine clinical utility. Currently, the same result cannot be accomplished for routine dual-modality whole body PET and CT, but is achievable with integrated PET/CT in a much shorter period of time.

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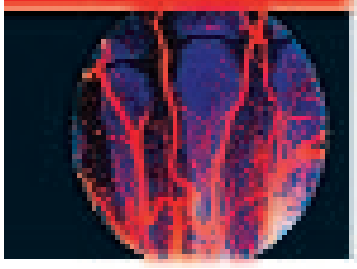

Finally, economic reasons for the use of integrated PET/CT need to be considered too. Costs for installation, maintenance and individual examination are not trivial. However, different imaging modalities have different inherent soft tissue contrast properties. Therefore, integrated PET/CT helps to overcome excessive use of several added imaging modalities within a stepwise approach. In addition, integrated PET/CT provided additional information in 41% more patients than with visual correlation of PET and CT.[2] Not to be forgotten, the number of non-therapeutic thoracotomies is significantly decreased not only by PET but also integrated PET/CT.[6]

In conclusion, it is time to move with the times – integrated PET/CT's time has come.

Key Learning

- Dual modality integrated PET/CT scanning offers medical, technical and economic advantages over PET or CT alone for imaging of thoracic lesions
- Integrated PET/CT offers improvement in:
  - distinguishing contiguity from invasion
  - specificity for lymph node staging and delineation between N1 or N2 stage
  - overcoming non-detection or discrepancies in detection of metastatic disease
- Integrated PET/CT enables:
  - provision of whole body images
  - compatibility of image capture, analysis and archiving
  - flexibility in patient scheduling
  - a reduction in whole body imaging time
  - less use of additional imaging modalities
  - fewer non-therapeutic thoracotomies
- Integrated PET/CT should be used for imaging of thoracic lesions

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