THE ADDED VALUE OF PET WITH CT

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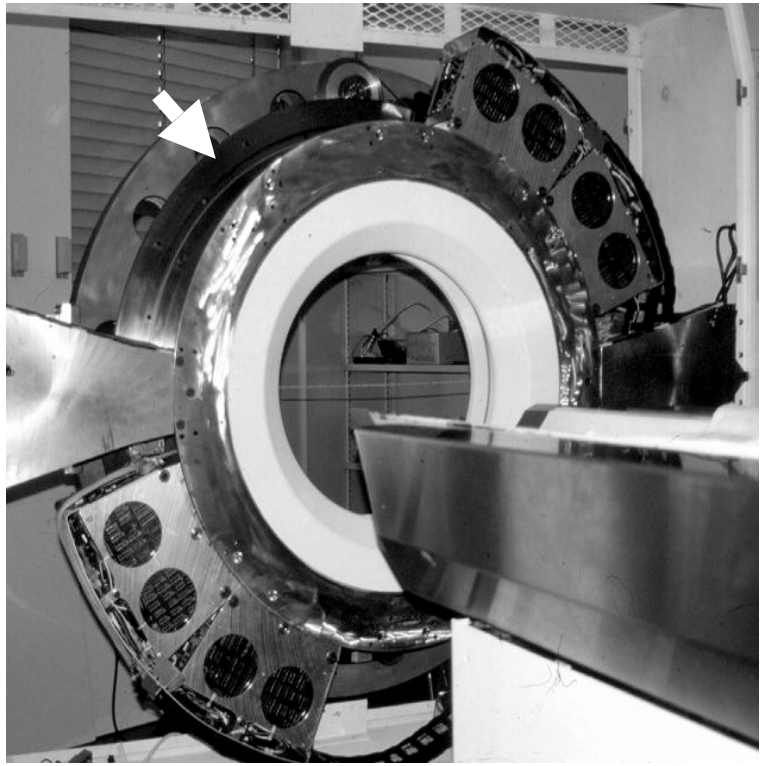
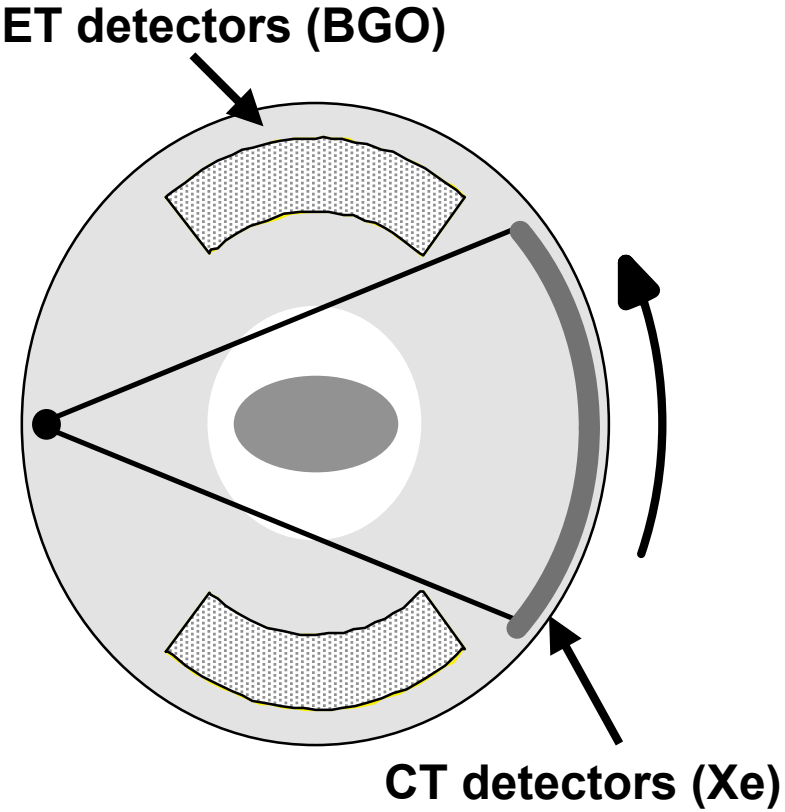
The PET/CT concept 1991



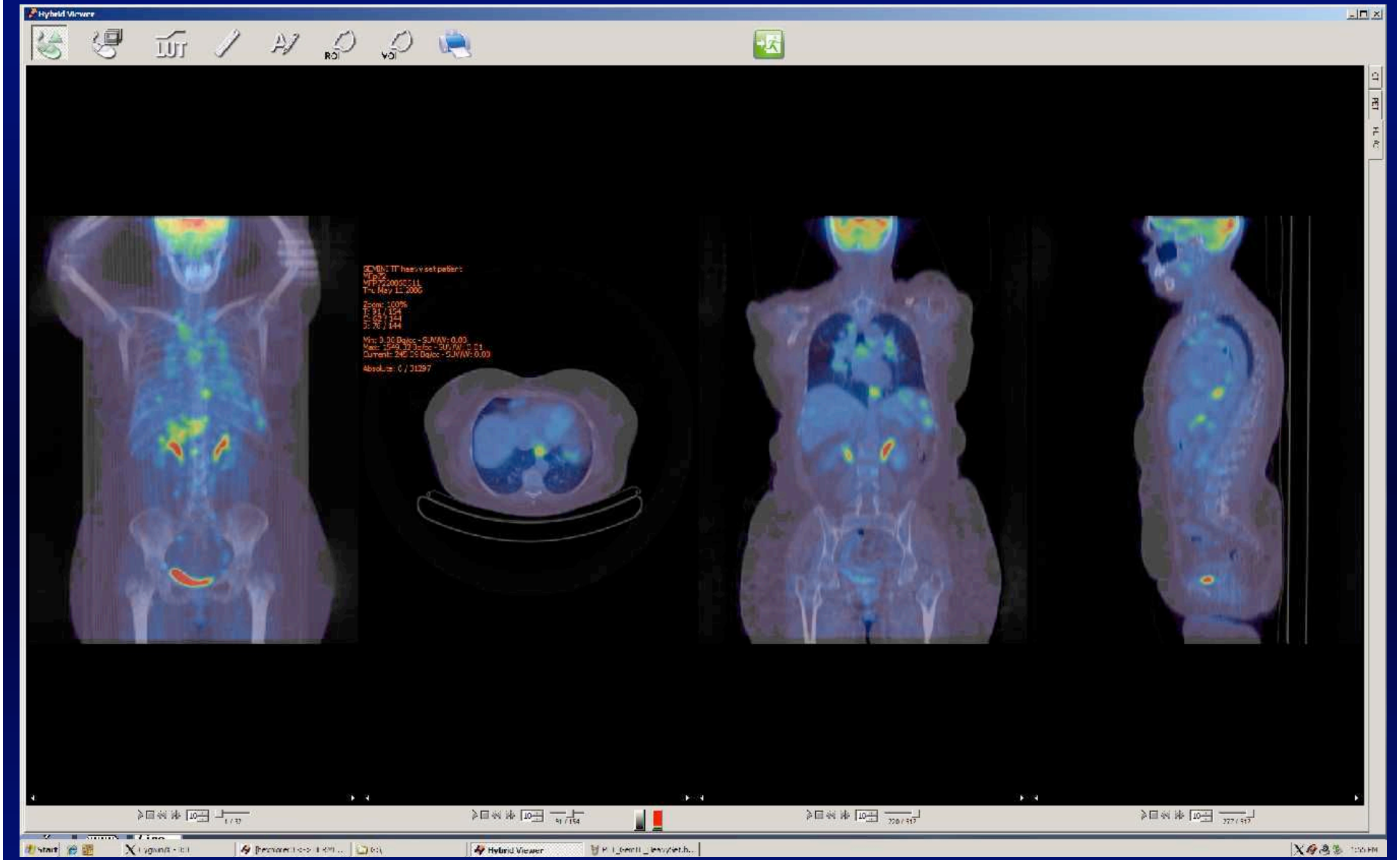
PRT-1



PET/CT: artist's impression

Slide courtesy of David Townsend *PhD*, University Hospital, Geneva

PET CT


Hybrid Viewer
LUT
ROI
VOI

The Potential Uses for CT in PET/CT

- Anatomical localisation of PET foci
- Fast transmission scanning
  - Increased throughput
  - Routine whole body attenuation correction (→SUV)
- CT characterisation of PET abnormalities
- Attenuation, scatter, partial volume corrections
- PET + CT = Improved Diagnostic Performance
- Enhanced comprehension of PET findings by referrers
- Utilisation in Radiotherapy Treatment Planning
- An alternative to CT alone in follow-up
- Integrating advanced CT data (*e.g.*, CT coronary angiography, calcium scoring) with PET functional data
- Potential future use in anatomically guiding PET image reconstruction
- Other…

A Bibliography of PET and PET/CT

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9. Gerth HU, Juergens KU, Dirksen U, Gerss J, Schober O, Franzius C. Significant Benefit of Multimodal Imaging: PET/CT Compared with PET Alone in Staging and Follow-up of Patients with Ewing Tumors. J Nucl Med 2007.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Staging of Non–Small-Cell Lung Cancer with Integrated Positron-Emission Tomography and Computed Tomography

Didier Lardinois, M.D., Walter Weder, M.D., Thomas F. Hany, M.D., Ehab M. Kamel, M.D., Stephan Korom, M.D., Burkhardt Seifert, Ph.D., Gustav K. von Schulthess, M.D., Ph.D., and Hans C. Steinert, M.D.

RESULTS

Integrated PET–CT provided additional information in 20 of 49 patients (41 percent), beyond that provided by conventional visual correlation of PET and CT. Integrated PET–CT had better diagnostic accuracy than the other imaging methods. Tumor staging was significantly more accurate with integrated PET–CT than with CT alone ($P=0.001$), PET alone ($P<0.001$), or visual correlation of PET and CT ($P=0.013$); node staging was also significantly more accurate with integrated PET–CT than with PET alone ($P=0.013$). In metastasis staging, integrated PET–CT increased the diagnostic certainty in two of eight patients.

CONCLUSIONS

Integrated PET–CT improves the diagnostic accuracy of the staging of non–small-cell lung cancer.

Summary of Selected PET/CT Abstracts from the 2003* Society of Nuclear Medicine Annual Meeting

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CONCLUSION

Despite the obvious limitations of short printed abstracts, several conclusions can be drawn. First, PET/CT permits the localization of molecular abnormalities and enhances the confidence of readers in discriminating abnormal from normal areas of hypermetabolism. Second, PET/CT imaging has a variable impact on staging and management of cancers. For instance, PET/CT changed stage and management in 20%–30% of patients with lung cancer and in >30% of patients with breast cancer. In contrast, no significant impact of PET/CT was reported in the diagnosis and management of patients with lymphoma or ovarian cancer. Future investigations will need to identify those cancer patients for whom PET/CT offers a diagnostic and prognostic advantage over PET alone.

*PET/CT was introduced in 2001

Significant Benefit of Multimodal Imaging: PET/CT Compared with PET Alone in Staging and Follow-up of Patients with Ewing Tumors

Hans U. Gerth[1], Kai U. Juergens[2], Uta Dirksen[3], Joachim Gerss[4], Otmar Schober[1], and Christiane Franzius[1]

[1]Department of Nuclear Medicine, University Hospital Münster, Münster, Germany; [2]Department of Clinical Radiology, University Hospital Münster, Münster, Germany; [3]Department of Pediatric Hematology and Oncology, University Hospital Münster, Münster, Germany; and [4]Department of Medical Informatics and Biomathematics, University Hospital Münster, Münster, Germany

J Nucl Med 2007; 48:1932–1939
DOI: 10.2967/jnumed.107.045286

As determined by lesion-based analysis, the sensitivity, specificity, and accuracy of PET were 71%, 95%, and 88%, respectively; the corresponding values for the hybrid PET/CT technique were 87%, 97%, and 94% ($P < 0.0001$). The areas under the curve in the ROC analysis were 0.82 for PET and 0.92 for PET/CT ($P < 0.0001$), and that in the L-ROC analysis was 0.66 for PET. **Conclusion:** PET/CT is significantly more accurate than PET alone for the detection and localization of lesions and improves staging for patients with Ewing tumor. The hybrid technique is superior to PET alone in terms of sensitivity, specificity, and accuracy, mainly because of the detection of new lesions.

Original article

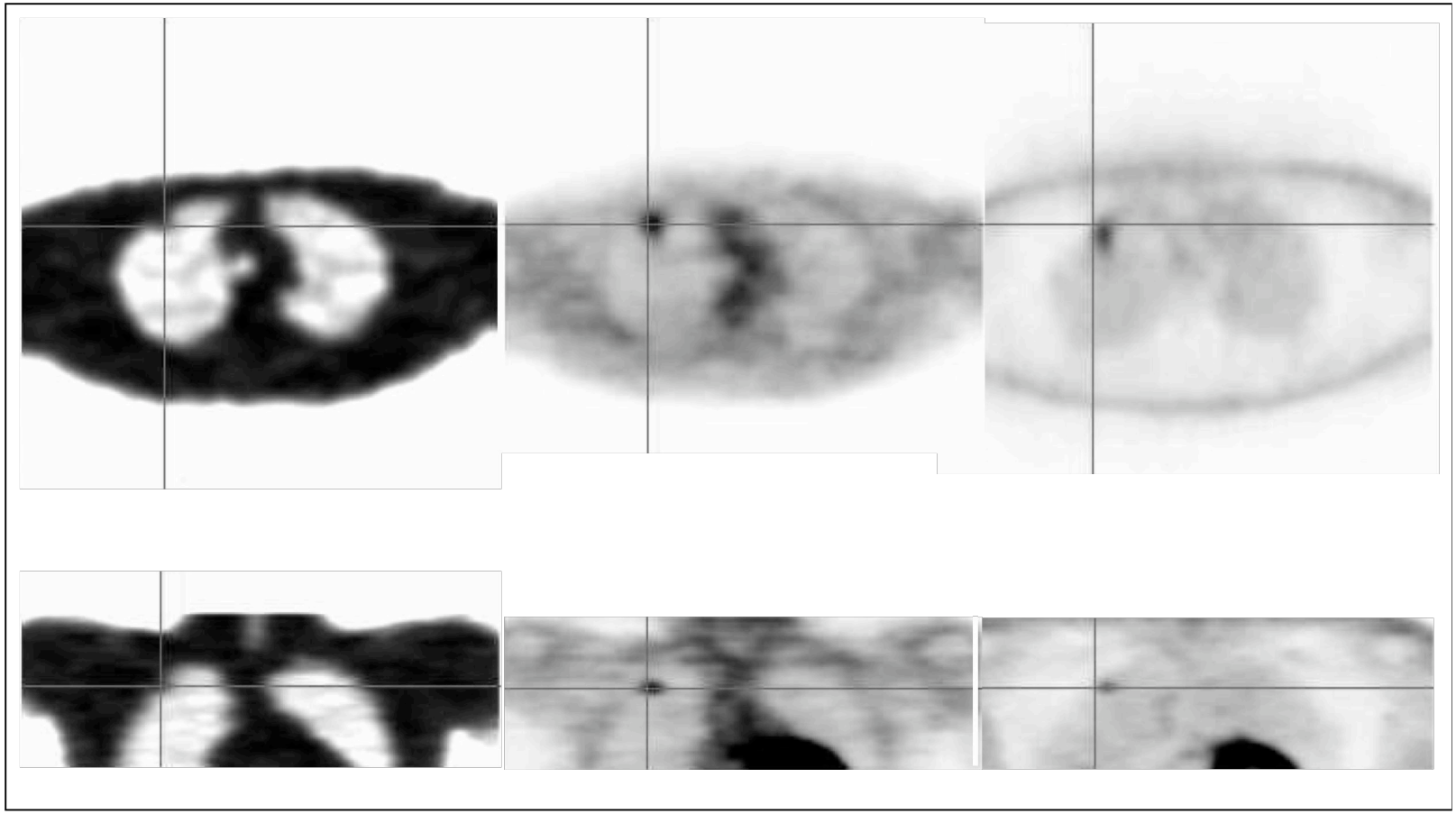
Nuclear Medicine Communications

SPECT/CT imaging using a spiral CT scanner for anatomical localization: Impact on diagnostic accuracy and reporter confidence in clinical practice

Paul J. Roach, Geoffrey P. Schembri, Ivan A. Ho Shon, Elizabeth A. Bailey and Dale L. Bailey

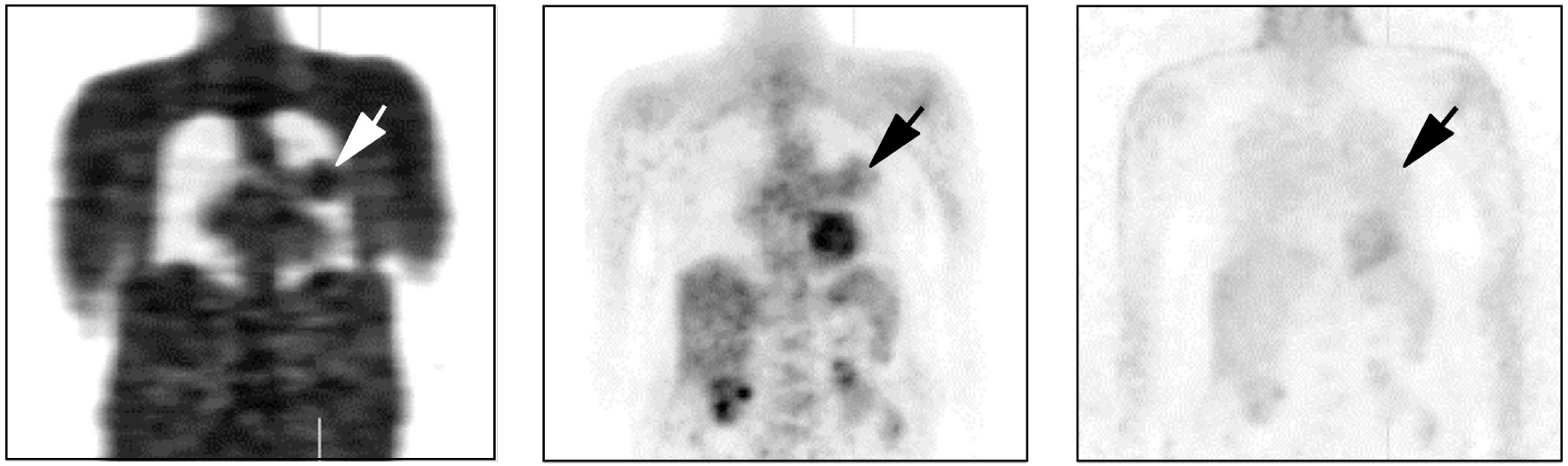
Conclusion Use of integrated SPECT/CT with a high spatial resolution, spiral CT used for anatomical localization improves accuracy and reporter confidence in clinical practice. As a result, final reports were different in 56% of the cases, including being significantly different in 26% patients compared to reporting with planar/SPECT alone. *Nucl Med Commun* 27:977–987 © 2006 Lippincott Williams & Wilkins.

PET – [^{18}F]-FDG



Attenuation Reconstruction Emission - With AC Emission - No AC

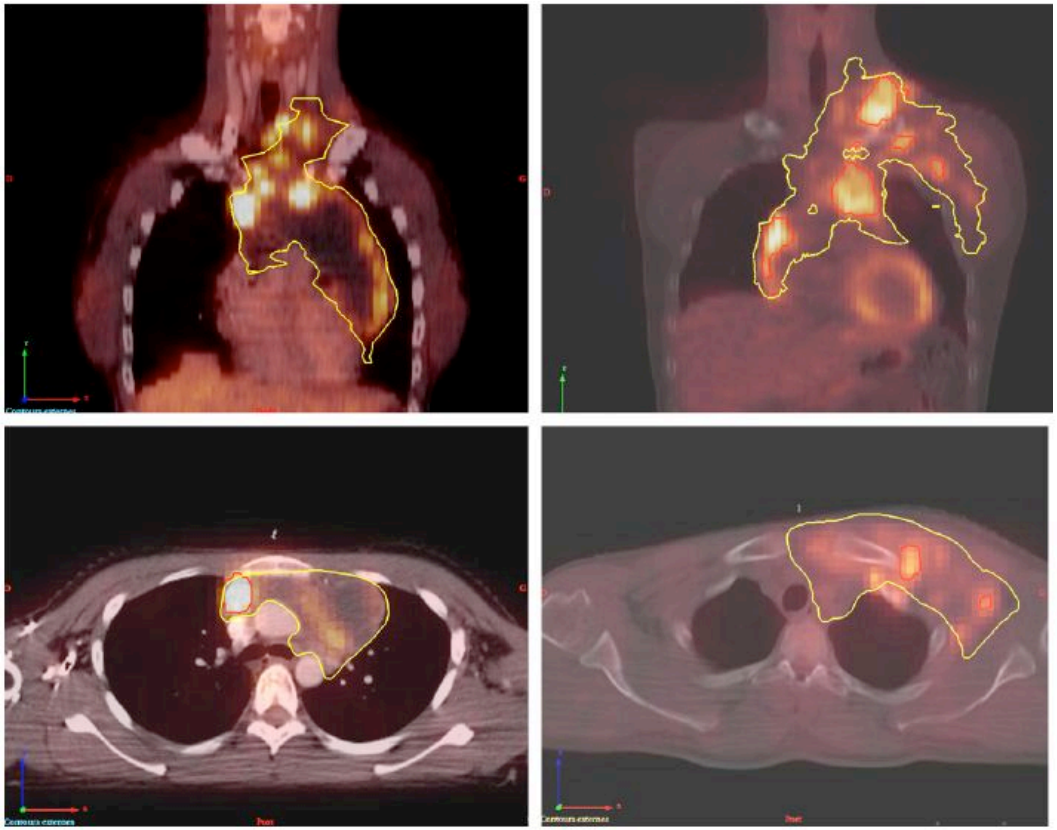
PET – [^{18}F]-FDG

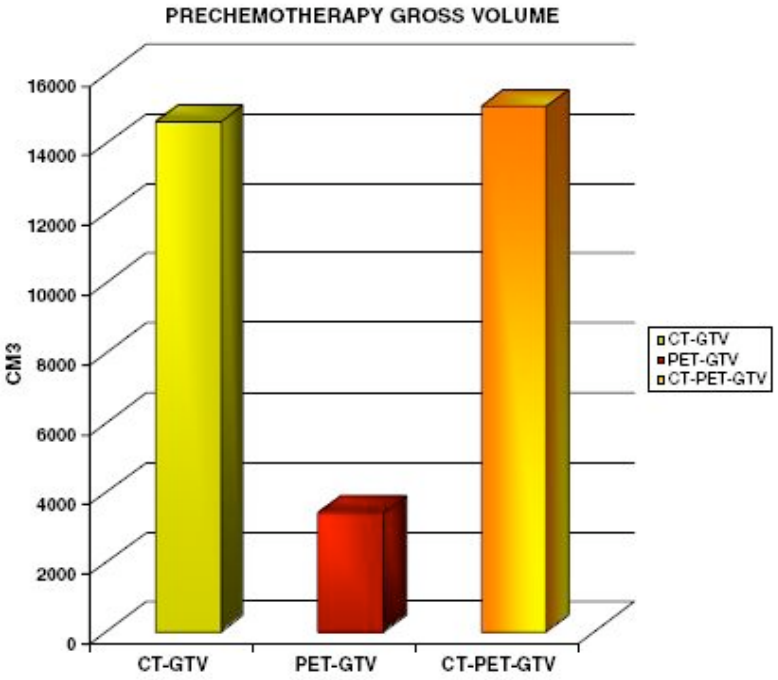


Attenuation **AC** **Non-AC**

From: Bai C, Kinahan PE, Brasse D, Comtat C, Townsend DW, Meltzer CC, et al. An Analytical Study of the Effects of Attenuation on Tumour Detection in Whole-Body PET Oncology Imaging. *J Nucl Med* 2003;44(11):1855-1861 (with permission)

PET/CT in RTP





What is the biological significance of FDG-PET-positive areas?

On average, only 25% of the anatomical volume was PET avid (range 0–54%). This signifies that approximately 75% of the tumor mass would not have been visualized if FDG-PET had been performed alone. Interestingly, rates of chemotherapy-induced shrinkage were similar for the tumor mass seen on CT and on FDG-PET (mean = 68% and 67%, respectively). In other words, anatomic masses and metabolic areas are equally chemosensitive

T. Girinsky et al. / Radiotherapy and Oncology 85 (2007) 178–186

Improved quantitation for PET/CT image reconstruction with system modeling and anatomical priors

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(Received 27 March 2006; revised 21 June 2006; accepted for publication 4 September 2006; published 17 October 2006)

Accurate quantitation of positron emission tomography (PET) tracer uptake levels in tumors is important for staging and monitoring response to treatment. Quantitative accuracy in PET is particularly poor for small tumors because of system partial volume errors and smoothing operations. This work proposes a reconstruction algorithm to reduce the quantitative errors due to limited system resolution and due to necessary image noise reduction. We propose a method for finding and using the detection system response in the projection matrix of a statistical reconstruction algorithm. In addition, we use aligned anatomical information, available in PET/CT scanners, to govern the penalty term applied during each image update. These improvements are combined with Fourier rebinning in a clinically feasible algorithm for reconstructing fully three-dimensional PET data. Results from simulation and measured studies show improved quantitation of tumor values in terms of bias and variance across multiple tumor sizes and activity levels with the proposed method. At common clinical image noise levels for the detection task, the proposed method reduces the error in maximum tumor values by 11% compared to filtered back-projection and 5% compared to conventional iterative methods.
[DOI: 10.1118/1.2358198]

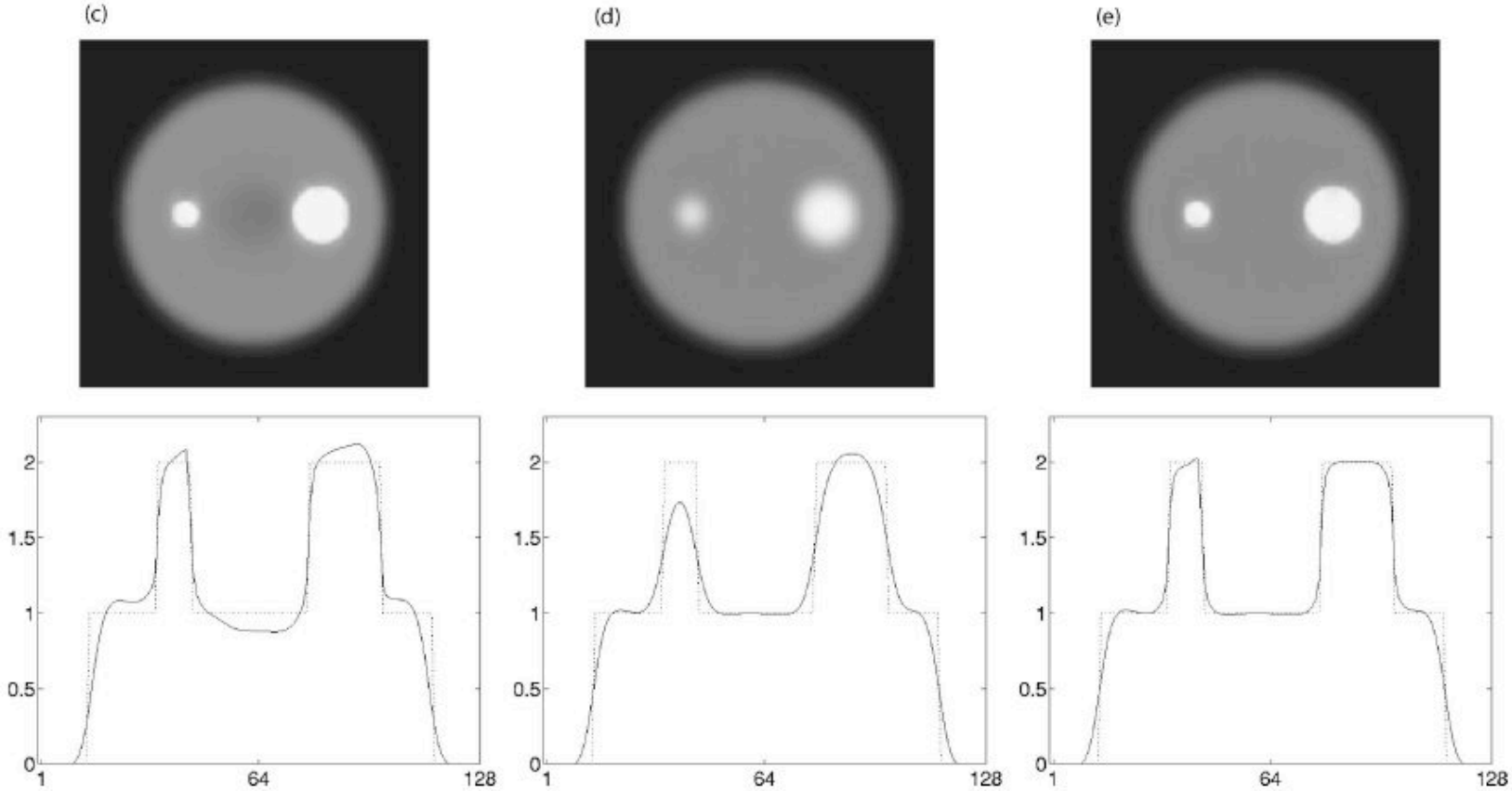

FIG. 5. Noiseless 2-D sample case showing benefit of system response function and boundary prior information in the reconstruction. Each reconstruction is displayed with a horizontal profile through the reconstruction (solid line) and through the true object (dotted line). (a) FBP 10 mm Hanning window. (b) Conventional PWLS. (c) PWLS+boundary info. (d) PWLS+SRF. (e) PWLS+SRF and boundary info.

CONCLUSIONS

Integrated PET/CT offers improvements:

- For the clinician reporting the scan:
  - improved anatomical localisation
  - improved diagnostic confidence
- For the scientist developing methodology:
  - improved reconstructed image accuracy
  - reduction of artefacts (attenuation, scatter, motion, PVE)
- Ultimately, for the patient being scanned