Clin Transl Imaging (2014) 2:443–444
DOI 10.1007/s40336-014-0088-5

GUEST EDITORIAL

# SPECT/CT: yesterday, today, tomorrow

**Torsten Kuwert · Orazio Schillaci**

Received: 5 October 2014 / Accepted: 10 November 2014 / Published online: 25 November 2014
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In the last two decades, advances in nuclear medicine have been driven mainly by the development of positron emission tomography (PET) imaging, whose value in oncology is unsurpassed. The strength of PET derives not only from its use of one of the most powerful radiopharmaceuticals available, i.e., F-18-deoxyglucose (FDG), but also from the fact that it offers superior image quality compared to single-photon emission computerised tomography (SPECT). Furthermore, SPECT is still largely performed as a stand-alone procedure, whereas PET imaging is now routinely performed in combination with CT (PET/CT).

The tremendous progress of PET/CT has, therefore, opened a discussion on the viability and future of single-photon imaging procedures. Despite this, a statistical survey conducted by the European Association of Nuclear Medicine in 2010 showed that the majority of in vivo nuclear medical procedures performed in Europe in that year were still conventional. Without doubt, the popularity of conventional nuclear medicine lies in its high cost efficiency. Economic considerations continue to be key factors in developed countries, and are of the utmost importance in less economically developed parts of the world. However, SPECT, too, has undergone dramatic improvements over the last two decades, even though they are less spectacular than those of PET. A major breakthrough was the development of the iterative image reconstruction techniques that substituted filtered back projection in the early 1990s [1]. Iterative image reconstruction allows corrections for the variables that confound image quality to be integrated directly into the reconstruction process; iterative image reconstruction has, since its introduction, been at the root of many technical improvements of SPECT. SPECT/CT hybrid imaging was first introduced as early as 1993 [2]. The CT component of the first of these hybrid systems used low-dose x-ray tubes that did not allow CT examinations of diagnostic quality. Nevertheless, thanks to these systems the benefit of SPECT co-registered with CT images was demonstrated and reported in several publications as a proof of principle [3]. The integration of spiral CT scanners into these hybrid devices in 2005 considerably increased the popularity of SPECT/CT hybrid imaging, as shown by a steep rise in pertinent publications from 2005 onwards (Fig. 1).

A multitude of articles has compared the diagnostic utility of SPECT/CT to that of stand-alone planar imaging and SPECT for various indications [3]. The results they report show that SPECT/CT increases the diagnostic accuracy of conventional nuclear medical imaging by up to 30 % in the fields of skeletal, tumour, inflammation and sentinel node scintigraphy. This dramatic improvement in diagnostic performance is based on several factors, the first being the possibility of anatomically localising foci of abnormal tracer uptake. This is particularly important when using radiopharmaceuticals that are highly specific for diseased tissue, but show only little or no uptake in normal anatomical structures. Examples include the iodine isotopes that are frequently used to stage thyroid carcinoma.

T. Kuwert (✉)
Clinic of Nuclear Medicine, University Hospital Erlangen, Erlangen, Germany
e-mail: orazio.schillaci@uniroma2.it

O. Schillaci
Department of Biomedicine and Prevention, University Tor Vergata, Rome, Italy

O. Schillaci
IRCCS Neuromed, Pozzilli, Italy

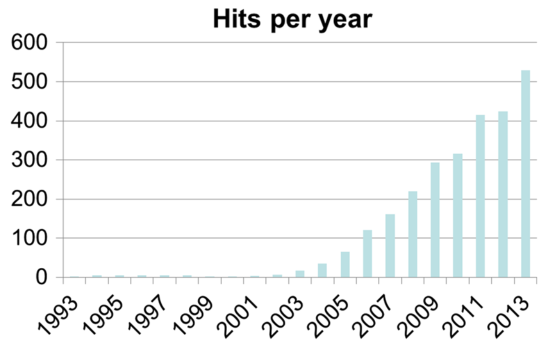


**Fig. 1** Number of hits per year as given by Web of Science for the key word "SPECT/CT" as of 18-09-2014

Analogously, sentinel node scintigraphy benefits from co-registration of SPECT with CT images as, in this case too, only the lymph nodes draining a tumour, and no other structures of the human body, are visualised.

The second possibility offered by SPECT/CT hybrid imaging is that of morphologically characterising foci of abnormal tracer uptake. This is particularly important in bone scintigraphy, as only SPECT/CT can accurately distinguish between benign and malignant causes of abnormal tracer uptake.

The third possibility offered by SPECT/CT is that of detecting CT abnormalities without correlation with SPECT, but it has been less explored scientifically. In the case of myocardial SPECT/CT, however, the CT images of SPECT/CT allow the detection of significant pulmonary pathology in subjects studied for coronary artery disease. This possibility may also be important for the detection of purely osteolytic metastases in skeletal SPECT/CT.

The fourth possibility offered by SPECT/CT is that of using information from the co-registered CT image dataset to improve the SPECT image quality. A striking example of this is CT-based SPECT attenuation correction, which leads, in principle, to better detectability of tracer-avid lesions located centrally in the human body. Furthermore, CT-based SPECT attenuation correction is able to increase the specificity of myocardial perfusion scintigraphy, at least in overweight men, and to offer improved outcome prediction in patients with known or suspected coronary artery disease. CT-based SPECT attenuation correction is also the basis for truly quantitative SPECT. This term designates techniques by which SPECT is used to quantify tissue radioactivity concentration in absolute units, e.g., as kbq/ml. The accuracy of quantitative SPECT/CT is below 10 %, at least for Tc-99m and for Lutetium-177. It is still unclear how quantitative SPECT may improve diagnosis, as this technology has only recently become available in commercial products. In principle, it should help in diagnosing diffuse rather than focal abnormalities of tracer uptake, as can be expected to occur in three-vessel coronary artery disease or disseminated metastatic spread to the skeleton. Furthermore, absolute quantitation of tracer uptake might be an attractive option for monitoring therapy in neoplastic diseases, analogously to FDG-PET. Last but not least, quantitative SPECT may increase the accuracy of dosimetry in radionuclide therapies, which is another field that has seen considerable technological progress in recent years, due to the development and increasing availability of new therapeutic radiopharmaceuticals, directed, for example, against the somatostatin receptors or prostate-specific membrane antigen.

SPECT/CT—although not as spectacular as PET—is coming of age. The editors of this issue of *Clinical and Translational Imaging* sincerely hope that the articles in this issue testify to this and will help this exciting new technology along its way to its certainly bright future.

**Compliance with ethics guidelines** Dr Kuwert occasionally gives lectures for Siemens Healthcare. The Clinic of Nuclear Medicine of the University Hospital Erlangen has a research cooperation with Siemens concerning the development and validation of SPECT/CT technologies.

**Human and animal studies** This article does not contain any studies with human or animal subjects performed by any of the authors.

## References

1. Hutton BF (2011) Recent advances in iterative reconstruction for clinical SPECT/PET and CT. Acta Oncol 50:851–858. doi:10.3109/0284186x.2011.580001
2. Seo Y, Mari C, Hasegawa BH (2008) Technological development and advances in single-photon emission computed tomography/computed tomography. Semin Nucl Med 38:177–198. doi:10.1053/j.semnuclmed.2008.01.001
3. Mariani G, Bruselli L, Kuwert T, Kim EE, Flotats A, Israel O, Dondi M, Watanabe N (2010) A review on the clinical uses of SPECT/CT. Eur J Nucl Med Mol Imaging 37:1959–1985. doi:10.1007/s00259-010-1390-8