Practical aspects of introducing advanced Nuclear Medicine technologies

H. Ryder, Dublin (IE)

Why are advanced technologies desirable?

Over the past ten years there have been several significant advances in technologies available to the nuclear medicine diagnostician, including the introduction of the modalities of SPECT-CT and PET-CT. The hybrid nature of these technologies allows for accurate and immediate fusion of functional images with their corresponding anatomical structural images, a considerable advance on computer-based image-fusion applications. These technologies have opened new avenues for clinicians in the diagnosis, staging and treatment of their patients in many fields, oncology being the most prominent. From being a 'sideline', the field of nuclear medicine as a discipline has now become a vital tool especially in oncology, orthopaedics, neurology and cardiology.

With regard to the benefits of SPECT-CT, the International Atomic Energy Agency (IAEA) said in a publication in 2008:

'By precisely localizing areas of abnormal and/or physiological tracer uptake, SPECT/CT improves sensitivity and specificity, but can also aid in achieving accurate dosimetric estimates as well as in guiding interventional procedures or in better defining the target volume for external beam radiation therapy… Clinical applications with SPECT/CT have started and expanded in developed countries. It has been reported that moving from SPECT alone to SPECT/CT could change diagnoses in 30% of cases.' [1]

In the case of PET-CT services the initial use of the low-dose CT scan was to delineate the areas interest and form the basis of accurate image attenuation correction. However the continual improvement and application of both the CT and PET components have vastly expanded the role of PET-CT by providing a 'one-stop-shop' by utilising the 16- or 64 slice CT scanners as fully diagnostic units.

'…nuclear medicine technologists, who are being asked to conduct exams unlike any they have done before. Staff must handle issues of contrast use, injectors, and screening of patients for allergies, and they must be ready to handle anaphylactic reactions, should they occur. They must also learn to apply protocols in a way that meets the same standard of care provided in radiology departments.' [2]

The onus therefore is on the nuclear medicine technologist to rise to these challenges to provide the appropriate expertise for these services. We must also ensure that the increased requirements in training, techniques and understanding of the technologies involved are matched by the increased levels of patient care needed to produce the diagnostic quality images that will hopefully improve the prognosis of those who undergo these examinations.

Training and techniques

According to a study undertaken in 2000 nuclear medicine technologists have long-understood the need for further education, with up to 85% embracing the need for advanced practice career pathways [3].

The need to address and provide the education, qualifications and training of the radiographers and technologists who perform the scans utilising new technologies has been addressed many times, with the Technologist Committee of the EANM being extremely active in its role as educators and facilitators. There are now a number of courses available through the EANM Educational Facility in Vienna, held at different times over the year for both technologists and diagnosticians/therapists. However it is noted that although the need for international standardisation of training has been acknowledged, the inevitability of different countries still applying different personnel licensing requirements is predominant.

In 2002, the advent of hybrid technology prompted the Society of Nuclear Medicine Technologist Section (SNMTS) and the American Society of Radiologic Technologists (ASRT) to convene a consensus conference to 'discuss the personnel issues involved in performing fusion imaging'[4]. This was done with the aims of developing specific recommendations with regard to the training of these personnel. Although the focus was on PET CT units, but could be applied over a wide range of multimodality imaging equipment. One very strong thread within the discussion was the need for 'hybrid' technologists who would be able to harness both aspects of the modality of SPECT/PET and CT, i.e. those who are cross-trained in the technical and practical aspects of both nuclear medicine and CT. In practicality, there are very few radiographers and technologists who are dual-qualified, resulting in a wide variation in the level of confidence with which radiographers, radiation therapists and nuclear medicine technologists approach the techniques.

This lack of expertise in either of the two modalities could potentially (and inadvertently) have a deleterious effect on the flexibility of the service, affecting the patient throughput, areas of dose reduction, ability to counter potential imaging deficiencies and overall patient care. One nuclear medicine department in Ireland, which had hoped to open their new PET-CT unit with at least four radiographers who were dually-trained in both nuclear medicine and CT (to certification level and/or in-house), found that by the time the unit opened this pool had been dwindled to only one such operative. This was due to one member of staff being promoted to head the CT unit, one joining another hospital as a specialist radiographer to lead the nuclear medicine facility there, and the third was on maternity leave. The dynamics of the subsequent training then had to encompass, for the remaining members of the nuclear imaging staff, an introduction to the theories of the CT component of the PET-CT unit (beyond that already received in their basic radiography training).

National qualification and registration issues have also affected the role of the sole member of the scanning personnel in that same department, who is not a radiographer. This medical physics technician is highly trained and has over twenty years of experience, and is undertaking much of the work within the PET-CT department save in one area only – that licensing restriction prohibits her from initiating the CT portion of the scan, thus requiring a colleague to remain beside her until the AC map/ diagnostic CT scan has been performed. The same technician is now once again facing similar problems as a SPECT-CT unit has been recently installed in the nuclear medicine department of the same hospital.

At present only the lead radiographer within the unit has had the privilege of participating in both the basic and the advanced PET CT course in Vienna. However the other radiographers in the Irish hospital have had the definite benefit of having within its grounds the main teaching facility for an accredited postgraduate MSc course in Radionuclide Imaging. One module of the course focuses on PET-CT, and over two days there are in-depth lectures to which radiographers other than the expected students are encouraged to attend. Thus all graduates of the MSc course have a more-than-basic theoretical understanding of the modality.

Operational management of the service – challenges and solutions

As nuclear medicine technologists and radiographers become more attuned to their role in either SPECT-CT or PET-CT, setting the parameters of each individual patient's scan preparation and scan requirements is often within the remit of the scanning personnel. Although each incoming request is vetted by the nuclear medicine radiologist or physician with regard to the appropriate scan, the detail of the protocol required is generally set by the technologist.

For example, decisions must be made with regard to whether the CT portion of scan should be:

I. a low-dose localisation scan or a full diagnostic scan;

II. if intravenous iodine contrast media should be administered;

III. if oral iodine contrast media is required;

IV. if patient positioning is to be altered to accommodate the physical limitations of the patient;

V. if specific techniques need to be applied e.g. for head/neck pathology/melanoma imaging;

VI. any requirements for a doctor to administer sedation to a patient e.g. due to claustrophobia or to other medical problems that may result in excessive patient movement to the detriment of the scan.

Similarly, the requirements for the SPECT or PET portion of the scan must be assigned, including the region of body to be examined, appropriate administered dose of the radiopharmaceutical, acquisition time, speed of rotation of gamma cameras,

For many of these decisions to be made with confidence, full access to relevant patient medical history is required by the assigned scanning personnel, including any allergies/contra-indications to iodine-based contrast media; access to recent laboratory/pathology results with regard to the patient's renal functions; access to any previous relevant imaging procedures, especially images and results of previous CT, MRI, SPECT-CT or PET-CT examinations; knowledge of upcoming examinations or interventional procedures.

It must be noted that in the author's PET-CT department, by requiring that previous CT reports and/or images be made available prior to a patient's appointment for a PET-CT scan, the possible duplication of a diagnostic-quality CT scan (within 8 weeks) can be avoided and the subsequent reduction in received radiation dose to the patient is significant. Patients who subsequently go on to have repeated staging PET-CT scans are also exempt from requiring full diagnostic scans.

By researching all of these in advance of the patient appointment, patient flow through the department can be assigned on a daily basis thus improving patient throughput hence reducing overall patient waiting times, both for their appointment and on the day of examination. At present in the author's PET-CT department a maximum of 11 patients per 8.30am-5pm working day may be scanned – this number may drop to 10, dependent on the need for diagnostic CT scans or diagnostic head/neck imaging, which do require more imaging

time in both the PET and the CT portions.

To achieve this end, the radiographer/technologist often has to commit to considerable interaction with the patient prior to the scan procedure commencing. With regard to PET-CT, for example, detailed instructions regarding appropriate diet and fasting requirements prior to the patient's appointment are essential for the overall success of the examination and production of diagnostic quality images. Although the departmental secretary is often the initial point of contact for the patient, the radiographer/technologist is often better placed to expand upon the need for compliance with these dietary instructions, especially when the patient is diabetic. This communication, often by appointment letter but also followed telephone contact, can also allow the patient to discuss any aspects of the test that might be worrying them. The potential for claustrophobic negativity can sometime be overcome with verbal reassurance, thus reducing the need for pharmacological support.

On the day of the examination, a more in-depth interview should take place prior to the injection of radioactive tracer, so as to fully inform and enrol the patient as an ally for the successful completion of his or her diagnostic scan. This obviously reduces the need for patient contact once the patient becomes the source of radiation.

Initiating and standardising scan protocols is essential for the safe and smooth running of a nuclear medicine department, and these protocols should be written and saved, either in electronic or hardcopy file, and be readily-available for all scanning personnel to refer to at any time. The protocols should be reviewed frequently and updated as necessary, after consultation with the nuclear medicine radiologist/physician.

Auditing newly installed technologies for future notation

To fully appreciate the changes that happen when new technologies are installed within a nuclear medicine department, the use of clinical audit is essential to provide benchmarks against which further refinements of service might be made. In the author's hospital audits have already been made, including:

Doses received by patients from both diagnostic CT scans and low-dose localisation CT scans.

Patient waiting times within the PET CT department

Personnel annual received doses and projections within regard to increased patient throughput (both whole body and extremity doses)

A retrospective audit will be initiated shortly into the number of diagnostic CT quality scans performed versus low-dose localisation CT scans, to see if vetting and changing of patient criteria for a diagnostic CT scan by both radiologist and radiographer has resulted in reducing the number of diagnostic CT scans and hence patient dose received.

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Clinical benefits of advanced Nuclear Medicine technologies

N. Sheehy, Dublin (IE)

Nuclear medicine technology has undergone enormous technical evolution over the last decade. In this presentation I will examine two general areas and demonstrate the benefits that accrue in the clinical management of the patient and the important changes that are needed in acquiring and interpreting the studies.

The common availability of combination PET/CT and SPECT/CT cameras – These new machines have resulted in major changes in workflow in nuclear medicine departments. I will discuss, with clinical examples, how we approach these difficulties in our unit. In particular, I will focus on how the protocols of the CT and Nuclear medicine aspect of each examination can be tailored to maximise the potential information from each study.

Development of new reconstruction methods – New mathematical reconstruction methods are being developed in both SPECT and planar imaging that allow reconstruction of datasets with fewer counts without loss of image

quality. This can be used to reduce patient dose or decrease imaging time. I will discuss the potential benefits of these approaches.

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