

WHITE PAPER OF THE EUROPEAN ASSOCIATION OF NUCLEAR MEDICINE (EANM) AND THE EUROPEAN SOCIETY OF RADIOLOGY (ESR) ON MULTIMODALITY IMAGING (*)

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(*) This paper is a result of working party negotiations of EANM and ESR delegations throughout the time period of October 2005 – February 2007. All authors contributed equally to the production of this paper. This paper was approved by the executive committee of the EANM, the executive council of the ESR, the general assembly of the European Association of Radiology and by the executive committees of the UEMS sections of nuclear medicine and radiology, respectively. The document was presented at the EANM strategy committee meeting, which was held in London in February 2007. It was also presented at both the EANM advisory council meeting and the EANM extraordinary delegates meeting that took place in Vienna in March 2007.

Summary

New multimodality imaging systems bring together anatomical and molecular information and require the competency and accreditation of individuals from both nuclear medicine and radiology. This paper sets out the positions and aspirations of the European Association of Nuclear Medicine (EANM) and the European Society of Radiology (ESR) working together on an equal and constructive basis for the future benefit of both specialties.

EANM and ESR recognise the importance of coordinating working practices for multimodality imaging systems and that undertaking the nuclear medicine and radiology components of imaging with hybrid systems requires different skills. It is important to provide adequate and appropriate training in the two disciplines in order to offer a proper service to the patient using hybrid systems. Training models are proposed with the overall objective of providing opportunities for acquisition of special competency certification in multimodality imaging. Both organisations plan to develop common procedural guidelines and recognise the importance of coordinating the purchasing and management of hybrid systems to maximise the benefits to both specialties and to ensure appropriate reimbursement of these examinations.

European multimodality imaging research is operating in a highly competitive environment. The coming years will decide whether European research in this area manages to defend its leading position or whether it falls back behind other leading economies. Since research teams in the Member States are not always sufficiently interconnected, more European input is necessary to create interdisciplinary bridges between research institutions in Europe and to stimulate excellence. EANM and ESR will work with the European Institute for Biomedical Imaging Research (EIBIR) to develop further research opportunities across Europe. European Union grant-funding bodies should allocate funds to joint research initiatives that encompass clinical research in diagnostic imaging in conjunction with research in mechanical and electronic engineering, informatics and biostatistics, and epidemiology.

Introduction

Nuclear medicine and clinical radiology are separate medical specialties recognized by the European Union. The two specialties have similarities and differences. Both specialties offer both diagnostic and therapeutic elements and both utilise radiation for a substantial part of their work. While clinical radiology has had a greater focus on the demonstration of anatomy and pathology, nuclear medicine has placed more emphasis on biology and pathophysiology. This demarcation has, however, become less evident as newer imaging techniques have been introduced.

Technological developments have contributed in bringing this relationship into closer perspective. Over the last few years, positron emission tomography (PET) has become accessible to a large number of centres for diagnostic purposes. PET and single-photon emission computed tomography (SPECT) use a variety of radiopharmaceuticals to obtain in vivo images of the biochemistry of disease. PET and SPECT scanners have now been linked to computed tomographic (CT) scanners, which are digital radiological systems that acquire data in the axial plane, producing images of internal organs of high spatial and contrast resolution. The combination of PET or SPECT and CT as a single unit provides spatial and pathological correlation of the abnormal metabolic activity, allowing images from both systems to be obtained by a single instrument in one examination procedure with optimal co-registration of images. The resulting fusion images facilitate the most accurate interpretation of both PET or SPECT and CT studies. CT attenuation maps from these integrated systems are used for rapid and optimal attenuation correction of the PET or SPECT images. In addition, PET-CT and SPECT-CT images are used to improve radiotherapy planning and to guide intervention. This process of integration of imaging systems has progressed to magnetic resonance (MR).

At present, ^{18}F -fluorodeoxyglucose is the only PET radiopharmaceutical which is widely available for human use. ^{11}C -labelled compounds are confined to research centres with

cyclotron capabilities, while active investigations have been conducted to develop other ^{18}F - and ^{68}Ga -labelled radiopharmaceuticals that are now entering clinical studies. PET and SPECT are currently the most powerful molecular imaging techniques used in clinical diagnosis, although developments in MR are progressing rapidly. However, unlike MR, PET and SPECT images often lack anatomical landmarks and are interpreted in correlation with images obtained by anatomical imaging modalities in order to locate more precisely the regions of abnormal metabolic signal or enhanced/reduced tracer uptake.

Optimal CT protocols for use in combination with PET and SPECT are being developed. These include the administration of appropriate contrast agents to avoid attenuation artefacts and optimal procedures to minimise potential mismatches due to respiration and patient positioning between PET or SPECT and CT examinations. Respiratory and cardiac gating devices are under development. The CT component of PET-CT has now evolved to a fully diagnostic, contrast-enhanced CT examination.

Research in the field of imaging has become a multidisciplinary process, with radiologists and nuclear medicine specialists working not only with clinicians from other disciplines but also with physicists, biochemists, physiologists, computer experts and bioengineers.

It is therefore important that the two specialties review their relationship to maximise the success of the technical advances for our patients and to avoid a damaging confrontation which would be negative for the profession, for the future of both specialties and for the public that we serve. It is also important that the two specialties work closely together in multidisciplinary research to maximise patient benefit and technical progress.

To this end the European Association of Nuclear Medicine (EANM) and the European Society of Radiology (ESR) have agreed to work together to produce a common position. Diagnostic PET-CT, SPECT-CT and PET-MR bring together anatomical and molecular information and require the competency and accreditation of individuals from both specialties

(Nuclear Medicine and Radiology). New multimodality imaging systems carry enormous potential for rapid and efficient diagnosis but also challenge established patterns of professional practice and patient care.

Indications for multimodality imaging

Oncological diseases

1. Staging and restaging of primary, residual and recurrent tumours: Diagnostic PET-CT, SPECT-CT and ultimately PET/SPECT-MRI are integrated diagnostic procedures with very powerful capacities to determine tumour spread when used by physicians who understand and are trained in imaging methodologies, tumour biology, treatment options and the functional changes induced by the various therapeutic procedures.
2. Therapy monitoring and individual risk assessment: Response evaluation appears to be a major indication for multimodality imaging. For the moment it is mainly used to assess prognosis, but in the future it might be broadly used to guide patient management based on the individual response pattern.
3. Image-guided intervention: Improved pre-operative localisation of tumour spread will greatly assist the interventional radiologist and surgeon, who may be further helped by intra-operative probe detection of tumour deposits. Biopsies might also be guided by these combined imaging modalities, which can indicate and localise the part of the tumour with the highest density of proliferating cells. These methods improve radiation oncology by determining the biological target volume.

Neurological diseases

1. Diagnosis and follow-up of dementia: With new treatments being developed, it is extremely important to identify objective reproducible parameters of response. Hybrid brain imaging has the potential to play this role.

2. Diagnosis, staging and assessment of treatment response in Parkinson's disease and other neurodegenerative disorders: Studies of the neuronal transporters and receptor mechanisms allow confirmation of the diagnosis, disease staging and assessment of the effect of treatment.

Cardiovascular diseases

1. Diagnosis of coronary artery disease (CAD): The major advantage of the integrated approach to the diagnosis of CAD is the added sensitivity of PET or SPECT and CT angiography. With integrated PET/SPECT-CT systems, the limitations of both techniques can be overcome, leading to improved diagnostic capabilities.
2. Guiding management of CAD: Not all coronary artery stenoses are flow limiting, and PET or SPECT stress perfusion imaging complements the anatomical CT data by providing functional information on the haemodynamic significance of such stenoses, thus allowing more appropriate selection of patients who may benefit from revascularisation procedures. MR has proven to be useful for the evaluation of ventricular function, myocardial perfusion and viability. Future developments aimed at combining MR with PET in a single PET/MR instrument may further enhance its role.

Other diseases

Multimodality imaging has also been shown to be of value in the diagnosis of other conditions, such as infection and inflammation.

Training in multimodality imaging

High-level training in both nuclear medicine and radiology is a prerequisite for high-quality image interpretation with hybrid systems. There are several ways to achieve such training; the choice will differ between countries owing to differences in infrastructure and legislation. Training should be properly structured and comprehensive and should be conducted in

accredited training centres. It should incorporate the principles and all modalities of both specialties to allow the trainee to acquire a full understanding of the possibilities and difficulties of each technique and its medical background, and provide the basis for participating in the necessary and inevitable evolution of multimodality imaging. Refresher type courses can prepare for specific training or refresh knowledge, but cannot replace appropriate on site training. It is not acceptable for training to be focussed on a single technique.

Training options

1. Comprehensive training in both specialties, clinical radiology and nuclear medicine, in those countries where it is possible for the individual to practice both specialties and where such dual specialty training can be obtained. Such training gives the trainee the possibility of ultimately practicing in one or both of the specialties and of billing appropriately (see below). The duration of the entire training programme in both specialties would most likely be neither politically nor economically acceptable in many European countries.
2. An adjusted period of training in the other specialty in addition to full training in the primary specialty. Such a structure would facilitate acquisition by nuclear medicine specialists or radiologists of the necessary training in the other specialty after having completed full training in their primarily chosen specialty. The adjusted additional training programme should be defined to provide a broad foundation of knowledge in the second specialty and should not be confined to a single technique such as CT or PET or a single clinical application. For nuclear medicine specialists, besides relevant radioprotection issues, training will include the physical principles and practical clinical skills of ultrasound, CT and MR imaging. For radiologists, besides relevant radioprotection issues, training will include knowledge of radiopharmacy and

radiotracer biokinetics and the physical principles and practical skills of SPECT and PET. The training need not include therapeutic interventional radiology or radionuclide therapy. The core of the additional training would be dedicated to hybrid imaging. For radiologists, part of the nuclear medicine component should be undertaken during the fourth and fifth years of training. Maintenance of radiology skills during this time would be mandatory. For nuclear medicine specialists, part of the radiology component should be undertaken during the fourth and fifth years of training. Maintenance of nuclear medicine skills during this time would be mandatory. The remaining part of the training would then be obtained with an additional year fully dedicated to the second specialty, giving a total of 6 years' training for both specialties. The exact duration of the training is necessarily subject to local regulations, which may vary from country to country. Nonetheless, the general time scale as outlined in this option should be considered as the model. Such additional training will lead to a special competency certification.

3. Potential future integration of training: an incorporated training in nuclear medicine and radiology taking the form of a cross-over or integrated training programme, where both specialties agree and recognise a training curriculum which encompasses the principles of all imaging modalities of both specialties. The curricula of both specialties would be adapted to include knowledge of anatomy, cell biology, genetics and physiology as well as the normal requirements of the physical basis of all imaging modalities and patient safety.

Each country should establish a training schedule that ensures the accomplishment of appropriate training in both specialties, having in mind that this cannot be achieved by merely performing a certain number of studies with one or the other technique. Only thorough training will give the necessary insight into anatomical and functional aspects of the various

modalities, their interpretation with respect to patient-tailored treatment and risk assessment, and finally the further development and refinement of multimodality imaging.

Interim arrangements for hybrid systems

There are numerous options available with regard to the future cooperation and integration of working practices. In the longer term these are best addressed by appropriate training models and programmes. However, the rapid dissemination of diagnostic PET-CT systems also requires interim measures to deal with the operation of the systems in order to ensure patient safety, cost-efficient practice and quality of care and diagnosis.

This working pattern would involve the nuclear medicine specialist managing and reporting the nuclear medicine component of the examination and the radiologist managing and reporting the anatomical and pathological component, with consultation between the two specialists to combine the data into a final diagnosis. In a health care environment where payment is made for service, each specialist would provide an account with regard to the part of the study that he/she is directly responsible for.

The advantage of this concept is that those fully trained in the specific modalities would interpret the images jointly, thus providing a high-quality result. At a practical level this concept requires careful organisation, cooperation and discussion between nuclear medicine and clinical radiology specialists.

Management and procurement of hybrid systems

Modern imaging equipment is expensive and, as all health care systems are under financial strain, it is important that the equipment that is purchased is utilised to a maximum degree.

The importance of combining anatomical and physiological data with PET and SPECT images is widely recognised, and this is demonstrated by the rapid rise in the purchase of hybrid systems and the decline in stand-alone PET and SPECT systems. It is important that

coordination of equipment requirements is undertaken between radiology and nuclear medicine at a local level to favour appropriate installation and balance of equipment. This process will need to be led by the two societies through the development of advice on the principles and practice of joint procurement and cooperation. Ultimately, sharing of multimodality imaging resources in European countries will depend on many circumstances, both locally and nationally.

Financial reimbursement for hybrid systems

It is clearly essential that there is adequate financial remuneration to individuals and departments for their work undertaken using hybrid systems. Financial arrangements for reimbursement vary considerably from country to country within Europe. It is therefore not appropriate for this paper to deal with this issue in detail. However, it is important that adequate resources become available for both specialties.

Finally, only properly trained specialists should be allowed to bill the studies accordingly. Comprehensive training in both specialties enables the practitioner to practice both specialties and to bill for the whole examination. Specialists who are trained in one or the other specialty only, should be allowed to bill only for the study for which they are certified. However, they must show that hybrid studies are performed in accordance with nationally or internationally accepted practice guidelines and comply with the local radioprotection rules.

Research and development

Extensive research has been undertaken in both the development and the clinical application of PET/SPECT-CT and more recently PET-MR, and these technologies continue to provide extensive research opportunities. There are many options for cooperation to deliver successful research programmes for both nuclear medicine and clinical radiology. In a major development the ESR has established the European Institute for Biomedical Imaging

Research (EIBIR) with the objective of coordinating a network of excellence of existing fundamental research departments and clinical departments, including all fields of biomedical imaging. This is now a legal entity and has received a grant from the EU and financial support from a number of major companies.

The EANM, as one of their research initiatives, has agreed to be a supporting organisation, and close involvement of nuclear medicine and clinical radiology in this initiative can only enhance the future research role of both specialties.

Conclusion

This paper sets out the positions and aspirations of the EANM and the ESR working together on an equal and constructive basis.

Both organisations:

1. are committed to working together for the future benefit of both specialties;
2. recognise the importance of coordinating working practices for multimodality imaging systems;
3. recognise that undertaking the nuclear medicine and radiology components of imaging with hybrid systems requires different skills;
4. recognise the importance of adequate and appropriate training in the two disciplines in order to provide a proper service to the patient by using hybrid systems;
5. propose training models with the overall objective of providing opportunities for the acquisition of special competency certification in multimodality imaging;
6. plan to develop common procedural guidelines;
7. recognise the importance of coordinating the purchase and management of hybrid systems to maximise the benefits to both specialties and of ensuring appropriate reimbursement of these examinations;
8. will work with EIBIR to develop further research opportunities across Europe.