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EANM® European Association of Nuclear Medicine

BIOMEDICAL IMAGING AND THERAPY FOR PERSONALIZED HEALTHCARE

EANM Benchmark Document on Nuclear Medicine Technologists' Competencies

written by the EANM Technologist Committee

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INTRODUCTION

Nuclear medicine is a medical speciality in which radioactive materials are used for diagnosis by imaging and non-imaging techniques and for therapy in many disease processes.

Nuclear medicine technologists (NMTs) and radiographers (NMRs) often perform similar roles; however, in many European countries they are separate professional groups and their training can be highly specific to nuclear medicine (NMTs). In all cases they are highly specialised and they work alongside other healthcare professionals to play highly responsible roles in patient care, management, imaging and radiation protection. They may have significant non-imaging roles within the radiopharmacy and laboratories and may also have involvement in radionuclide therapy procedures and PET-CT-aided radiation therapy planning. Some European countries have a tradition of advanced roles for NMTs/NMRs; examples include leading cardiac stress sessions, formal reporting of nuclear medicine images, requesting of X-ray imaging and administration of radiopharmaceuticals.

DEFINITIONS

An NMT is defined by the EANM and IAEA [1] as a health care professional who is able to undertake the whole range of nuclear medicine procedures. He/she is part of a team of healthcare specialists which may include physicians, physicists, radiochemists, radiopharmacists, other clinical scientists, nurses and others who support and care for the patient during diagnostic and therapeutic procedures, under the direction of a nuclear medicine physician.

The responsibilities of the NMT are to maintain the highest possible standard of results in the performed procedures, which may include imaging, non-imaging, labelling and therapeutic procedures, to maintain the highest standards of patient care and to deliver the lowest radiation dose to patients, staff and the public that is compatible with valid results [2].

The work of the technologist is not carried out by a single professional group since there is great variation in competencies, education and national regulation among European countries. National laws are the supreme judges on the tasks and educational requirements of professionals working in nuclear medicine.

With this in mind, the EANM Technologist Committee (EANMTC) started a long process of definition and harmonisation of procedures with the aim of achieving a consensus definition of tasks and education that may apply to all European nuclear medicine realities, defining high quality standards in procedures and patient care.

The first EANM consensus document on technologist competencies was published in 1998. Subsequently debate continued throughout Europe, and in recent years EANMTC has explored options for improvements, in collaboration with other actors such as the European Federation of Radiographers (EFRS), the Society of Nuclear Medicine and Molecular Imaging Technologist Section (SNMMI-TS), the European Society of Therapeutic Radiation Oncology RTT committee (ESTRO-RTT), the Australian and New Zealand Society of Nuclear Medicine (AZSNM) and national societies of nuclear medicine.

EANMTC has maintained a strong belief in consensus as the key word throughout this process, the goal being to define, in a realistic but optimistic manner, NMT competencies and the education necessary in order to achieve them.

DISCUSSION DOCUMENT ON ADVANCED PRACTICE

In June 2009, during the SNM annual conference in Toronto, EANMTC and SNMMITS agreed that a Euro-American working party would be established to consider creating a discussion document on advanced practice. It was recognised that any consideration of a definition for advanced practice would be predicated on an understanding or definition of entry-level practice. As a result, both types of practice would have to be considered. This discussion document outlined some of the background issues associated with advanced practice generally and specifically within nuclear medicine. The primary purpose of the document was to stimulate debate, on a Euro-American level, about the perceived value of advanced practice for NMTs and NMRs within nuclear medicine and to develop an internationally accepted list of entry-level competencies and scope of practice for NMTs and NMRs within nuclear medicine.

The working party developed a Euro-American consensus for entry-level and advanced practice competency. The aims were to provide a framework for a national and international initiative on how NMT and NMR roles and clinical career ladders might be developed, to facilitate learning from others' experience and to encourage NMTs and NMRs to take a critical look at and evolve, where possible, their professional roles. A draft consultation document

was written by August 2010, and key elements of this document have been presented at four conferences: World Federation of Nuclear Medicine and Biology, September 2010; EANM, October 2010; Croatian Radiography Conference, 2011; and SNM, 2011. Comments were received from delegates at these events, and some changes were made to the document. The document was finally presented at the 2011 EANM Conference in Birmingham.

The technology in nuclear medicine has evolved from the routine clinical use of rectilinear scanners in the 1960s to the routine clinical use of PET/CT scanners in the 21st century. Although the expectations and responsibilities of the NMTs and NMRs have increased greatly over the last four decades, in some instances these increases have not been accompanied by a formal recognition of their practice. Each country has its own requirements for becoming an NMT or NMR, and generally the requirements involve a programme of study that includes theory and practice. In many countries, there is a requirement to formally assess an individual's competence to practice and an individual's knowledge of the theory that underpins competence in the field. In addition to the marked variations in formative professional education between and within countries and the differences in expectations about the skill and ability of NMTs and NMRs upon qualification and entry into the field, there are also differences in post-qualification educational opportunities and requirements.

An entry-level competence and skill set might be defined as follows:

- The competence and skill set would be that considered necessary to ensure that nuclear medicine procedures are conducted to an appropriate level.
- The competence and skill set would be acquired during basic training or formative professional education.
- The scope of the competence and skill set would vary between countries, because of factors such as laws, politics, culture and economy.
- Any agreed-on international entry-level list of skills and competencies would risk being small because of the above factors.

Advanced practice might be defined as follows:

- The competence and skill set would be one that is acquired after basic training.
- The competence and skill set would be at a higher cognitive and clinical level than basic training or formative professional education.
- The competence and skill set would seek to improve patient care and management.

- The competence and skill set would seek to offer opportunities for clinical career progression.
- The scope of the competence and skill set would vary widely between countries, because of factors such as laws, politics, culture and economy.

During international consultation, questions were raised on definition of a minimum requirement for entry level. As a result of these questions, EANMTC set 2015–2016 as the deadline for preparation of a similar consensus document to state the minimum requirement in order for an individual to be considered an NMR or NMT.
For further details, refer to the bibliography noted in [3].

EFRS EQF LEVEL 6 DOCUMENT

The establishment of the EFRS is the result of a decision by an informal subgroup of the International Society of Radiographers and Radiological Technologists (ISRRT), which has worked at the European level for many years. The decision was taken to create a separate, independent and legally established body. 2007 was a preparatory year and in 2008 the EFRS was legally founded in the Netherlands. In 2009 it was decided to incorporate the universities which had been working under the EU-funded project called HENRE as affiliate members, with cooperation being pursued in accordance with the EFRS's educational aims while keeping the well-known name of HENRE for this new group. In 2015 it was decided to delete the HENRE name, because it originated some confusion. The affiliate educational institutions now cooperate as EFRS Educational Wing and are fully integrated in the EFRS organisation and action planning. Since then this group has grown in university membership from 18 to 55.
The first cooperation between EANMTC and EFRS was in the EC-funded tender project MEDRAPET, conducted between December 2010 and March 2013. The overall aim of this project was to improve implementation of the Medical Exposure Directive provisions relating to radiation protection education and training of medical professionals in the EU Member States [4]. The cooperation of EANMTC was endorsed by the EANM Dosimetry Committee. The role of EANMTC principally related to Chapter 6, "Learning outcomes for radiographers", and more specifically to the KSC table on pages 69–70 [5]. The cooperation was extremely fruitful and led to widespread implementation of the part relating to nuclear medicine-specific radiation protection, which was found to be satisfactory by both EANM and EFRS.

The good outcome of this first cooperation led EANMTC and EFRS to keep an on going a discussion on NMT and NMR competencies.

After initial approaches in which both partners agreed on adopting a "realistic-optimistic" point of view and on creating a document based more on principles than on details, EANMTC entered some consultation exercises within the EANM and NMT communities. These consultation exercises raised an issue with EFRS, since their idea of consensus referred only to radiographers, without any medical professional or medical association involved. Their project was intended to be "from radiographers for radiographers", including an association like the EANM only at a later stage.

EFRS proceeded, adhering to their deadline and developing within the scope of the European Qualification Framework (EFQ) a benchmark document outlining the entry-level competencies required of a radiographer new to the field of therapy / diagnostic imaging / nuclear medicine at the EQF level 6 (bachelor). EANMTC was consulted by EFRS about this document. The document contains generic knowledge, skills and competencies (KSC) applicable to all professional fields, complemented by specific KSC tables for medical imaging, radiotherapy and nuclear medicine. The purpose of this document was not to produce or impose curricular content but to provide a set of learning outcomes as a benchmark for institutions that currently offer or are in the process of developing radiography educational programmes at EQF Level 6. For individual radiographers who have previously qualified at the sub 1st cycle Bologna level (equivalent to EQF Level 5), this document will provide opportunities to seek individual recognition at EQF Level 6 through a process of recognition of their formal and informal learning after qualification; they will thus be able to demonstrate achievement of the stated learning outcomes at EQF Level 6. . In a "validation round", the document was circulated by EFRS to all related European umbrella organisations (ESR, EANM, EFOMP and ESTRO) for comment. As a result minor changes were incorporated in the final version.

EANM also addressed a more specific comment to EFRS EQF 6 benchmarking document. The general KSC table is well written and complete, being easily applied to nuclear medicine. However, some statements were considered too generic and, as it stands, the document does underrepresent the depth and scope of nuclear medicine. Assuming that, upon qualification, a diagnostic radiographer would also meet all the core requirements for working in nuclear

medicine, EANM suggested to clarify detail further to ensure that the high standards of required education are met. The starting point, however, is that each professional group decides about its own scope of action, while taking advice from closely related professions.

CONCLUSIONS

EANMTC wants to remain consistent with the works and consultations that have been produced and undertaken during the past 6 years. EANMTC is also willing to cooperate with EFRS in updating educational standards for technologists and radiographers operating in nuclear medicine.

Harmonisation of education and competencies will lead to a great advancement in daily practice and patient care in all nuclear medicine contexts in Europe. In merged education, too, it is important to set highly detailed standards for nuclear medicine practice, aimed at ensuring the acquisition of more generic skills and other imaging competencies. Hybrid imaging must be approached by competent professionals able to deal with technological advances, patient and staff safety, clinical requests and quality assurance.

All this work must be undertaken in a consensus environment in order to prevent roadblocks to this path, which would cause only discomfort for European NMTs.

Nuclear Medicine Technologist Knowledge, Skills And Competencies for EQF Level 6 (Bachelor Degree)

Structure of the Document

The European Qualification Framework (EQF) was implemented in 2008 as a tool to tackle the challenges presented by the recognition of diplomas and certificates issued in the different national education and training systems of the 28 Member States of the EU [7]. This motivated an effort to adjust existing professions to a standardised model across Europe.

The acceptance of the EQF model Europe-wide provided the main motivation for development of an EQF level 6 [8] for the nuclear medicine technologist (NMT). Although regional accreditation dictates the professionalisation process for NMTs, the description of outcomes following the Knowledge/Skill/Competency model can be adapted without prejudice regarding the educational path practiced in the different countries of Europe. This first step in adapting to the current trends in professional qualification will provide the basis for clearer delineation of NMT competencies and also the perfect opportunity to translate recent developments in nuclear medicine technologies into competencies in clinical practice, research and education of NMTs.

The structure presented in the 1998 Document on Competencies, with EANMTC authorship, provided one of the main operational matrices when producing the EQF for NMTs. However, the time interval between the "old" and the "new" document led to conceptual gaps, in terms of NMT competencies, that needed to be filled. The increasing autonomy of NMTs in nuclear medicine departments was also taken into account in the new document, ensuring that it reflects current standards.

The core competencies of the NMT following the EQF model were divided into 13 groups:

1	Establishment of a nuclear medicine department and equipment installation
2	Departmental organisation
3	Patient care and welfare
4	Instrumentation quality assurance (imaging, non-imaging and radiation protection instruments)
5	Radiopharmacy including PET and SPECT
6	Performance of imaging including PET and SPECT
7	Hybrid imaging
8	Performance of in vitro tests
9	Radiopharmaceutical therapy procedures
10	Radiation protection
11	Occupational health and safety
12	Research
13	Education

These 13 items were conceptually considered to cover the whole range of tasks and aims relevant to the competencies of contemporary NMTs.

1. Establishment of a nuclear medicine department and equipment installation

Knowledge	Skills	Competencies
K1.1 Have knowledge about a nuclear medicine department blueprint design	**S1.1** Collaborate with the chief technologist and clinical director in the department organisation and material placements	**C1.1** Take responsibility in the definition of the technologist's procedures
K1.2 Possess information (e.g. technical guides, whitepapers) regarding the equipment which is to be installed	**S1.2** Collaborate with the scanner manufacturers and nuclear medicine medical physics expert (MPE) in the equipment installation and set up	**C1.2** Take responsibility and keep a record of the installed equipment's technical set up
K1.3 Understand the different material needs and organisational conditioning required for both diagnostic and therapeutic procedures	**S1.3** Collaborate with the chief technologist in decisions regarding the materials that will be needed for patient care and performance of imaging	**C1.3** Organise the department facilities and logistics in order to facilitate the performance of diagnostic and therapeutic procedures (e.g. prepare SOPs, forms, etc.)
K1.4 Know the range of activities and isotopes that will be manipulated at the department	**S1.4** Collaborate with the MPE in the calculation of radioactive activities and definition of radiation protection areas (e.g. monitoring area, controlled area and exclusion area)	**C1.4** Be aware of the logistics and aspects of department design relevant to radiation protection

2. Departmental organisation

Knowledge	Skills	Competencies
K2.1 Understand the requested procedures and determine the department's dynamics	**S2.1** Organise and prepare the agenda of the department, in accordance with the requested exams	**C2.1** Take responsibility for accomplishment of the department's agenda in a teamwork environment
K2.2 Identify the specific needs of the department	**S2.2** Optimise the patient throughput for each item of equipment	**C2.2** Be aware of the trade-off between patient throughput and adequate patient care
K2.3 Know the materials involved in order to perform each exam and therapy	**S2.3** Order the necessary materials to perform each procedure	**C2.3** Take responsibility for ensuring that all equipment is available for the performance of the demanded diagnostic or therapeutic procedure
K2.4 Possess knowledge of the legal requirements regarding transport and discharge of radioactive materials	**S2.4** Order the necessary radiopharmaceuticals required for diagnostic and therapeutic procedures	**C2.4** Ensure that the correct radiopharmaceutical and activity are available for all diagnostic and therapeutic procedures
K2.5 Possess basic knowledge of departmental management	**S2.5** Organise technologist staff to ensure the performance of the requested procedures, in collaboration with the chief technologist	**C2.5** Contribute positively to the optimisation of your department's organisation, maintaining an assertive posture towards colleagues and patients
	S2.6 Prepare simple information to give to the patient: information about the general procedure and specific preparation	
	S2.7 Organise clinical workflow so that radioactive patients have minimal contact with at-risk individuals (e.g. pregnant females)	

3. Patient care and welfare

Knowledge	Skills	Competencies
K3.1 Understand each patient's pathology and subsequent needs, according to the clinical information and medical prescriptions	**S3.1** Prepare the department/room for the arrival of each patient, and special conditionings	**C3.1** Ensure that the patient is provided with the necessary material and environmental means to the accomplishment of all diagnostic and therapeutic procedural steps.
K3.2 Know the sociocultural factors that are inherent to each patient	**S3.2** Provide the patient with the items noted to be important to his or her sociocultural need	**C3.2** Be aware of the differences between patients, respecting their individuality: beliefs, religions, creeds, etc.
K3.3 Comprehend the psychological factors that influence the patient's behaviour	**S3.3** Identify patients' individual needs	**C3.3** Identify patients' sudden needs and ask for medical evaluation when required
K3.4 Understand the stages of development in paediatric patients and their specific needs	**S3.4** Utilise the department's resources to meet the needs of children and their parents during the medical procedures	**C3.4** Be aware of the psychological stress to both parents and children that may arise from nuclear medicine procedures
K3.5 Understand the legal basis of patient consent when performing diagnostic or therapeutic procedures	**S3.5** Be able to explain all the procedures and to establish patient collaboration	**C3.5** Take responsibility for obtaining patients' consent for diagnostic and therapeutic procedures, for explaining procedures to the patient and for responding appropriately to their questions
K3.6 Know the different radiopharmaceutical administration procedures	**S3.6** Administer the radiopharmaceuticals to patients, where applicable	**C3.6** Take responsibility in the act of radiopharmaceutical administration, where applicable
K3.7 Know the risks of each radiopharmaceutical/ contrast medium administration (contraindications, patient risk factors, side effects), how to behave in an emergency situation and which antagonistic medication is recommended	**S3.7** Exclude risk factors in the patient, evaluate the patient's response to the radiopharmaceutical/ contrast medium injection, recognise side effects and provide emergency care (including basic life support) if needed	**C3.7** Recognise critical situations for and/or after administering radiopharmaceuticals/contrast media; recognise side effects and the need for emergency care and/or antagonistic medication

K3.8 Comprehend the need for adjuvant pharmaceuticals and their specificities for patient administration (furosemide, Lugol, ACE inhibitors, nitrates etc.)	**S.8** Be able to administer adjuvant pharmaceuticals, under medical prescription (furosemide, Lugol, ACE inhibitors, nitrates etc.), where applicable	**C3.8** Take responsibility for the administration of adjuvant pharmaceuticals, under medical prescription, where applicable
K3.9 Know the correct patient preparation for diagnostic and therapeutic procedures	**S3.9** Check the patient preparation and evaluate the need for any additional action prior to the start of the exam/therapy	**C3.9** Be aware of the importance of correct patient preparation and interfere if anything has been forgotten or is still open
K3.10 Understand the theory of each cardiac stress test	**S3.10** Perform cardiac stress tests according to the cardiologist's prescription, where applicable	**C3.10** Actively participate in cardiac stress tests, where applicable
K3.11 Understand the environmental and material needs of the patient in order to accomplish each step of the exam/therapy	**S3.11** Provide the patient with the environmental and material tools for fulfilment of the exam	**C3.11** Be aware of the specificities of each exam and its particular needs and take responsibility for providing the patient with the environmental and material tools for fulfilment of the exam
	S3.12 Ensure patient surveillance, comfort, privacy and safety.	

4. Instrumentation quality assurance (imaging, non-imaging and radiation protection instruments)

Knowledge	Skills	Competencies
K4.1 Understand the physics and equipment theory underpinning each QA procedure	**S4.1** Identify and prepare the materials needed to perform the QA procedures	**C4.1** Take responsibility for interpreting QC tests to determine whether nuclear medicine equipment is in accordance with the manufacturer's specification
K4.2 Understand which particular aspect of the imaging apparatus is being tested for each QA procedure	**S4.2** Perform SPECT and PET QA, according to the MPE plan	**C4.2** Raise an alert when the results of the QA test are outside the acceptance limits
K4.3 Be able to explain in which way the QA procedure influences the clinical value of the acquisitions and images	**S4.3** Perform dose calibrator or other counting equipment QA, according to the MPE plan	**C4.3** Be aware of the potential hazard to the patient that can be caused by a missed QA procedure
K4.4 Understand the physical units that are being measured and the meaning of acceptance limits	**S4.4** Take corrective measures if the QA tests are not passed (including camera inactivity)	**C4.4** Critically judge the relevance of the performed QA and QC checks (or their omission)
K4.5 Have a basic knowledge of the standard NEMA procedures used in scanner calibration	**S4.5** Ensure that all QA materials and software are up to date and currently calibrated	**C4.5** Ask for engineering support when needed
K4.6 Understand the importance of QA in standardisation and clinical trials		**C4.6** Take responsibility for performance of the QA tests in accordance with the advised schedule
K4.7 Have knowledge of the guidelines/good practice documents relating to the regularity with which each QA test should be performed		

5. Radiopharmacy including PET and SPECT

Knowledge	Skills	Competencies
K5.1 Understand the radiopharmaceutical process behind the ^{99}Mo/^{99m}Tc generator and all the other available types of generator	**S5.1** Be able to elute all types of generator (e.g. the ^{99}Mo/^{99m}Tc generator)	**C5.1** Install and elute all types of generator (e.g. the ^{99}Mo/^{99m}Tc generator)
K5.2 Have knowledge of the specific QA tests relating to the purity of the eluate	**S5.2** Perform QA test of the eluate	**C5.2** Be able to evaluate the QA test result relating to the eluate prior to kit labelling
K5.3 Recognise the chemical and physical differences between the different radioisotopes and cold kits, including their production and the storage requirements	**S5.3** Follow the procedures for performance of radiopharmaceutical radioactive labelling and be familiar with the chemical interactions between the radionuclide and the cold kit during the labelling process	**C5.3** Take responsibility for radiopharmaceutical labelling and storing
K5.4 Understand the pharmacological differences between the available radiopharmaceuticals, their purposes and their quality requirements	**S5.4** Perform QA tests of the locally labelled kits	**C5.4** Critically interpret and record the results of the QA test, taking responsibility for their subsequent usage
K5.5 Distinguish PET from SPECT radiopharmaceuticals and be familiar with the recommended reference activities for each	**S5.5** Calculate the patient- and examination-dependent activity	**C5.5** Determine the recommended and correct activity to be administered to each patient
K5.6 Understand the range of aseptic techniques available for radiopharmaceutical preparation	**S5.6** Apply aseptic techniques throughout the handling of radiopharmaceuticals for injection, including the radiolabelling of kits	**C5.6** Take responsibility for the maintenance of radiopharmaceutical aseptic condition
K5.7 Understand the ALARA principles (as well DRLs and patient characteristics) concerning the preparation of doses and the differences between paediatric and adult activities	**S5.7** Use the ALARA principles	**C5.7** Take responsibility for preparing the correct amount of radiopharmaceutical for administration
K5.8 Have knowledge on cyclotron radiopharmaceutical production	**S5.8** Integrate a cyclotron unit multidisciplinary team, participating on radiopharmaceutical production	**C5.8** Perform optimisation procedures in conformity with ALARA principles to minimise occupational and patient exposure

6. Performance of imaging including PET and SPECT

Knowledge	Skills	Competencies
K6.1 Understand the principles of PET and SPECT imaging	**S6.1** Perform PET and SPECT imaging	**C6.1** Be capable of performing PET and SPECT imaging autonomously
K6.2 Know the difference between the available types of gamma camera imaging technique (dynamic, static, gated, tomographic and whole body)	**S6.2** Be able to adequately match the type of imaging technique to the information needed (e.g. dynamic versus static)	**C6.2** Follow the set procedure to acquire the required kind of images
K6.3 Know the difference between the available PET imaging techniques (2D, 3D, list mode, dynamic acquisition, gated and parametric imaging – 4D)	**K6.3** Apply the correct imaging technique that delivers the best diagnostic value in PET imaging	**C6.3** Take responsibility for image acquisition, processing and presentation in order to ensure that images are of optimal diagnostic value
K6.4 Know the acquisition parameters, their influence on image quality and the consequences when they are changed	**S6.4** Be able to adapt the image acquisition conditions to the clinical context in order to maximise the diagnostic value of the prescribed examination	**C6.4** Be autonomous and able to optimise the image acquisition conditions and parameters when necessary (e.g. patient-related limitations or customised protocols)
K6.5 Understand the concepts of sinogram, filtered backprojection, radon transform, forward transform, analytical and iterative reconstruction methods	**S6.5** Apply the correct reconstruction method to obtain a diagnostically valuable image	**C6.5** Take responsibility for the delivery of diagnostically valuable images and critically evaluate the influence of reconstruction parameters on image interpretation in cooperation with the nuclear medicine physician
K6.6 Know the different kinds of artefact and know how to avoid and correct them	**S6.6** Be aware of possible artefacts and pitfalls and be able to avoid or detect and correct them	**C6.6** Participate in decisions about the need for extra images due to artefacts. Take responsibility for the performance of the diagnostic procedure referring to a suitable standard, ensuring that no repeat examination is required because of technical deficiency
K6.7 Understand the importance of PET imaging for RT planning and its requirements	**S6.7** Perform PET image acquisition for RT planning in cooperation with the radiotherapy technologist	**C6.7** Take responsibility for the PET acquisition and cooperate with the radiotherapy and radio-oncology department in a multidisciplinary spirit

7. Hybrid imaging

Knowledge	Skills	Competencies
K7.1 Understand the principles of hybrid imaging	**S7.1** Be able to perform SPECT-CT, PET-CT and PET-MR	**C7.1** Be responsible for hybrid image acquisition: SPECT-CT, PET-CT, PET-MR
K7.2 Know the specific requirements regarding patient care and positioning in order to achieve good quality of both anatomical and functional images	**S7.2** Perform patient positioning taking into account specific requirements regarding patient care specificities when performing both SPECT/PET and CT/MR	**C7.2** Take responsibility for patient positioning and care during both image acquisitions
K7.3 Know the quality standards to ensure a good quality fused image	**S7.3** Be able to control the quality of the fused image	**C7.3** Be responsible for the quality of the co-registered images
K7.4 Understand issues and limitations relating to post-processing and alignment	**S7.4** Be able to perform image fusion post-processing	**C7.4** Take responsibility for the image processing/ alignment post acquisition
K7.5 Have knowledge of the acquisition conditions and their applicability to each patient's condition and needs	**S7.5** Be able to modify/adapt acquisition conditions to reflect each patient's needs	**C7.5** Take responsibility for and record the acquisition conditions applied to each patient
K7.6 Understand the added value provided by CT and MR in relation to the nuclear medicine images and the physical meaning of the findings	**S7.6** Be able to use CT and MR for attenuation correction and/or diagnostic applications	**C7.6** Be able to autonomously perform CT and MR for attenuation correction and/or diagnostic applications
K7.7 Catalogue typical artefacts encountered on fused images	**S7.7** Identify and minimise artefactual variants on fused images (in either the acquisition or the processing phase)	**C7.7** Properly identify and record artefacts present on fused images
K7.8 Know the different administration procedures for contrast media which might be needed for hybrid imaging (i.v. or oral)	**S7.8** Administer all these types of contrast media, where applicable.	**C7.8** Take responsibility for the administration of contrast media under medical prescription, where applicable.
K7.9 Have a sound theoretical basis regarding pharmacokinetics, pharmacodynamics and side effects of the used contrast media and have practical training in administering these contrast media and operating an injector, where applicable	**S7.9** Check that patient preparation is correct and – if it is – perform contrast medium administration (oral, intravenous). If necessary, perform a patient-dependent adaptation of the amount of contrast medium and the injection flow, where applicable	**C7.9** Take responsibility for contrast medium administration and operating a contrast medium injector, where applicable

8. Performance of in vitro tests

Knowledge	Skills	Competencies
K8.1 Understand the principles of RIA and IRMA	**S8.1** Set up and validate assays under safety conditions	**C8.1** Take responsibility for performing these tests and the complete spectrum of quality control procedures (assays and equipment)
K8.2 Understand the protocols and methodologies applied in both limited reagent (RIA) and excess reagent radioimmunoassay (IRMA)	**S8.2** Be able to follow the protocols and methodologies applied in RIA and IRMA and to detect problems (e.g. unsuitable serum and/or plasma)	**C8.2** Be responsible for correct test performance, use of the correct methodologies and good quality samples
K8.3 Have knowledge of laboratory safety procedures	**S8.3** Be aware of the potential biohazard posed by blood samples during manipulation	**C8.3** Take responsibility for maintaining laboratory safety procedures regarding the potential biohazard posed by blood samples
K8.4 Possess basic laboratory information management and counting equipment knowledge	**S8.4** Process the acquired data	**C8.4** Perform troubleshooting procedures
K8.5 Know and explain currently established radiation protection procedures during the handling of radioactive ***in vitro*** assays	**S8.5** Be able to practice radiation protection procedures during the handling of radioactive ***in vitro*** assays like RIA and IRMA	**C8.5** Be responsible for radiation protection procedures concerning manipulation of radioactive assays like RIA and IRMA
K8.6 Know the clinical relevance of ***in vitro*** procedures	**S8.6** Be able to explain the clinical relevance of ***in vitro*** procedures	**C8.6** Be part of the decision to reject an allocation because of lack of clinical relevance

9. Radiopharmaceutical therapy procedures

Knowledge	Skills	Competencies
K9.1 Be able to explain the principles and physiological foundations of nuclide therapy and know and be able to explain currently established radiopharmaceutical therapy procedures	**S9.1** Ensure that the preparation of therapeutic doses is well prepared and safely calibrated	**C9.1** Participate in the dose preparation for radionuclide therapy
K9.2 Have knowledge of radiobiology principles and their application in nuclide therapy	**S9.2** Prepare the patient and check for contraindications, possible pregnancy or breast feeding in women of reproductive capacity and teach the patient about radiation protection issues (e.g. toilet use and need for hospitalisation)	**C9.2** Play an essential part in the patient's preparation for a radionuclide therapy
K9.3 Explain the different stages involved in nuclear medicine therapeutic procedures	**S9.3** Be able to coordinate all steps that need to be taken by a multidisciplinary team during performance of a radionuclide therapy	**C9.3** Take responsibility for coordination of all procedures in a multidisciplinary spirit
K9.4 Have knowledge of the dosimetric foundations of nuclide therapy, including image-based dosimetry	**S9.4** Be able to perform all quality control checks and document their results	**C9.4** Take responsibility for planning and performance of all quality control checks and their documentation
K9.5 Know the legal patient discharge limits and be aware of the risks and hazards associated with the handling of nuclides in therapeutic procedures	**S9.5** Carry out radiation monitoring procedures	**C9.5** Be a part of the team responsible for discharging the patient
K9.6 Be aware of the contamination potential from patients and know the critical time after the administration of the radiopharmaceutical and the impact of pharmacokinetics and elimination	**S9.6** Carry out all procedures according to the current radiation protection and safety rules	**C9.6** Take responsibility in radiation protection procedures regarding the behaviour of the patient during the critical time after the administration of the radiopharmaceutical
K9.7 Understand the technical demands for imaging in therapeutic procedures	**S9.7** Be able to perform imaging procedures in a timely way, ensuring that all input data are concordant with the documentation	**C9.7** Optimise imaging protocols as to deliver the best quality images

10. Radiation protection

Knowledge	Skills	Competencies
K10.1 Know the official requirements for nuclear medicine departments with respect to clinical practice and research	**S10.1** Classify appropriately radiation areas within a nuclear medicine facility	**C10.1** Develop a specific plan for conduct of activities within the radiation area and restrict access of the general public and at-risk individuals (e.g. pregnant females) to active areas
K10.2 Be able to explain the functioning of the radiation measurement devices/detectors specific to nuclear medicine	**S10.2** Operate radiation measurement devices/ detectors and interpret the results in the context of nuclear medicine	**C10.2** Take responsibility for the appropriate registration of any measurement performed
K10.3 Use physics, concepts, principles and theories to explain the structure, functioning, characteristics, strengths and limitations, and use of medical devices in nuclear medicine	**S10.3** Perform all quality control procedures so as to ensure correct use of the devices/detectors involved in nuclear medicine, according to the responsible MPE plan	**C10.3** Take responsibility for the quality control checks and their documentation and present them to the responsible MPE
K10.4 Explain the application of beta decay, electron capture, positron decay, positron annihilation and isomeric transitions in nuclear medicine	**S10.4** Execute personal dosimetry monitoring as frequently as possible, simultaneously with standard obligatory monitoring	**C10.4** Develop a specific plan for conduct of activities which incorporates radiation protection and safety principles appropriate to the types of radionuclide being used. Coordinate radiation protection and dose optimisation initiatives with the MPE
K10.5 Explain the concepts of absorbed dose and effective dose and the ALARA principle as applied to patient safety/dose optimisation in nuclear medicine	**S10.5** Apply the concept of ALARA and the principles of time, distance and shielding to the radiation safety of workers and the public in nuclear medicine, mindful of the applicable dose limits	**C10.5** Be aware of the rationale underpinning the occupational and patient exposure limits, adopting optimisation or corrective radiation protection measures as a result of frequent personal monitoring
K10.6 Explain the risk/benefit justification for every procedure	**S10.6** Apply the justification principle according to the different categories of exposure	**C10.6** Critically evaluate and review whether the prescribed planned exposures are properly justified

K10.7 Know the national and international legislation governing radiation protection and the dose reduction principles relating to nuclear medicine procedures	**S10.7** Promote and implement the basic safety standards defined in the national and international legislation	**C10.7** Take responsibility for conforming to national regulations for all handling of unsealed radioactive substances
K10.8 Distinguish medical, occupational and public exposure	**S10.8** Develop strategies to enhance radiation protection in every task that involves radiation exposure	**C10.8** Optimise procedures/materials in order to enhance radiation protection
K10.9 Distinguish existing, planned, potential and emergency exposure situations	**S10.9** Comply with the stipulated reference levels for each exposure	**C10.9** Adopt measures and take responsibility for optimisation of any of the possible exposure situations
K10.10 Explain how radionuclides can be physically shielded (gamma, beta, positron)	**S10.10** Radioactive material handling in preparation of radiopharmaceuticals, respecting radioprotection principles and avoiding ambient contamination	**C10.10** Optimise acquisition parameters in order to reduce the absorbed dose to the patient and at the same time keeping the imaging diagnostic value
K10.11 For diagnostic procedures, explain what practical steps can be taken to minimise radiation risk to radiosensitive organs (e.g. thyroid)	**S10.11** Offer appropriate radiation protection advice to patients undergoing diagnostic nuclear medicine procedures	**C10.11** Take responsibility for handling unsealed radioactive substances in a manner that avoids accidental/unintended (potential) exposure of oneself and co-workers

11. Occupational Health and safety

Knowledge	Skills	Competencies
K11.1 Understand the potential biological and radiation hazards associated with the manipulation of unsealed radiation sources and the administration of radionuclides or manipulation of blood samples	**S11.1** Identify the major hazards in the workplace	**C11.1** Be aware of the individual responsibilities of nuclear medicine departments
K11.2 Know the basic safety standards for the protection of the health of individuals subject to occupational, medical and public exposures against the dangers arising from ionising radiation	**S11.2** Comply with the national law on manual handling of radioactive sources	**C11.2** Ensure that prevention and protection measures are taken to eliminate or minimise the risk to public safety from ionising radiation
K11.3 Understand and identify risk assessment measures	**S11.3** Perform effective and safe measures to minimise occupational risks and promote health and safety standards	**C11.3** Take responsibility for unnecessary radiation exposure of professionals and public (potential exposure) and implement corrective measures if needed
K11.4 Know the roles of health and safety authorities	**S11.4** Undertake health and safety training if so deemed by the health and safety authorities	**C11.4** Be aware of the different occupational exposure categories
K11.5 Understand the concept of emergency occupational exposure	**S11.5** Report accidents and dangerous occurrences	**C11.5** Keep individual medical records updated, including information regarding the nature of the employment and the results of medical examinations prior to employment
K11.6 Know the special dose restraints applied to individuals who require special monitoring (including pregnant staff, apprentices and students)	**S11.6** Undergo medical surveillance (as an exposed worker) by a health professional, whose capacity to act in that respect is recognised by the competent authority	**C11.6** Communication with the involved authorities (occupational health services, dosimetry services, radiation protection experts and MPEs)
	S11.7 Perform any further action considered necessary by the occupational health service for the health protection of exposed individuals, such as further examinations, decontamination measures, urgent remedial treatment or other actions identified by the occupational health service	

12. Research

Knowledge	Skills	Competencies
K12.1 Possess the theoretical basis required for research project design	**S12.1** Create a project or trial protocol that clearly sets the goals and requirements for a research project	**C12.1** Understand the elements that can lead to biased results
K12.2 Understand the principles of evidence-based nuclear medicine	**S12.2** Identify the principles involved in evidence-based practice and the research process	**C12.2** Be able to evaluate critically the methodological and analytical aspects of a research project
K12.3 Have a practical vision of the patient-related limitations to the applicability of the research protocol	**S12.3** Contribute a patient-centred vision on the development of the trial protocol	**C12.3** Ensure that the patient will be able to accomplish all steps of the trial protocol
K12.4 Possess a theoretical background on statistics and information management	**S12.4** Know the legal requirements involved in a research project and inform your local ethics committee accordingly	**C12.4** Adhere to international and national good research practice standards
K12.5 Know the formal requirements for the publication of research	**S12.5** Perform statistical tests and simple functional models of a research project	**C12.5** Critically review and take responsibility for the material to be published
K12.6 Possess in-depth knowledge on Good Clinical Practice (GCP) compliance	**S12.6** Work in a multidisciplinary spirit and communicate developments promptly	**C12.6** Be responsible for the implementation of new protocol trials in clinical practice

13. Education

Knowledge	Skills	Competencies
K13.1 Understand the pedagogic basis of knowledge transfer in the clinical and academic context	**S13.1** Develop activities for proactive education of students and technologist colleagues	**C13.1** Be aware of the impact that education has on the professional development of students and technologist colleagues
K13.2 Understand the nature of the multidisciplinary team that works or is involved in nuclear medicine	**S13.2** Adapt speech and terminology to the subject, so as to facilitate information/knowledge transfer	**C13.2** Self-evaluate performance relating to information/knowledge transfer
K13.3 Know the existing educational pathways of NMT professionalisation	**S13.3** Perform presentations and information for public education sessions	**C13.3** Optimise communication skills
K13.4 Be able to explain all procedures carried out in the exercise of nuclear medicine technology	**S13.4** Deliver communications in meetings and congresses aimed at NMT education	**C13.4** Participate in a realistic/optimistic diffusion of nuclear medicine procedures and principles
S13.5 Understand basic pedagogic notions to ensure effective student integration in clinical practice	**S13.5** Integrate students in the nuclear medicine department, encouraging their autonomy	**C13.5** Endow students with the theoretical and practical knowledge necessary for the performance of nuclear medicine procedures
K13.6 Understand the importance of continuous professional development in nuclear medicine practice	**S13.6** Be continuously educated and updated	**C13.6** Be actively involved in and responsible for continuous professional development activities

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