

Components of Professional Competence for Nuclear Medicine Physicians

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The nuclear medicine physician must have broad knowledge and experience in medicine as well as proficiency in and a commitment to the general competencies of patient care: medical knowledge, interpersonal skills and communication, practice-based learning and improvement, professionalism and ethical behavior, and an understanding of the basic applications of system-based practice. As the specialty advances, the nuclear medicine physician must be prepared to participate by extending the scope of nuclear medicine practice beyond that available at the time of training. Upon referral of a patient for consultation, a nuclear medicine physician specifically must be prepared to:

- a. Obtain a pertinent history.
- b. Perform a physical examination appropriate to the consultation.
- c. Select the most appropriate examination and perform diagnostic and therapeutic procedures in a manner that is safe to the patient, the staff, and the public.
- d. Interpret the results, arrive at a reasonable diagnosis through correlation of all available clinical and laboratory information, and issue a timely report.
- e. Recommend further study or treatment as appropriate.
- f. Assume responsibility for patient management or be an active participant in the management team if nuclear medicine therapy is indicated.
- g. Communicate effectively and promptly with patients and referring physicians.
- h. Develop and supervise programs for quality assurance and quality control.

- i. Provide expert consultation on the most appropriate and cost-effective examinations, both in nuclear medicine and in complementary imaging modalities.

The practice of nuclear medicine requires special knowledge in the following areas:

- I. Physical science
 - a. Structure of matter.
 - b. Modes of radioactive decay, the emissions accompanying radioactive decay, and the biologic implications of these emissions.
 - c. Interaction of radiation with matter and the biologic implications of this interaction.
 - d. Basic principles of imaging procedures, including single-photon planar imaging, SPECT, coincidence PET, attenuation and scatter correction, CT, MRI, magnetic resonance spectroscopy, ultrasonography, and Doppler ultrasonography.
- II. Instrumentation
 - a. Principles of radiation detection and detectors.
 - b. Imaging instrumentation such as the gamma scintillation camera, scanners, SPECT devices, and dedicated and hybrid PET devices; nonimaging instrumentation such as the γ -well counter, the scintillation probe, the liquid scintillation counter, radiation monitoring devices, the dose calibrator, and γ - or β -surgical probes.
 - c. Collimation for the various types of radiation detectors, with special emphasis on the characteristics of parallel-hole, diverging, converging, slant-hole, pinhole, fanbeam, and cone-beam collimators and their response to point, line, and plane sources.
 - d. Electronic instrumentation such as pulse amplifiers, pulse-height analyzers, scalers, and counting rate meters.
 - e. Image production and display technology, including photographic principles, sensitivity, resolution, contrast, latitude, film processing, and digital display technology.
 - f. Quality control principles and procedures.

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- III. Mathematics and statistics
- Fundamental concepts of mathematics, including algebra, geometry, and calculus.
 - Fundamental concepts of statistics, including probability distributions, parametric and non-parametric statistics, and counting statistics.
 - Principles of medical decision making, including Bayes' theorem, receiver-operating-characteristic analysis, comparative accuracy of diagnostic tests, comparative effectiveness of therapeutic procedures, and principles of clinical study design and analysis.
 - Mathematic models of biologic systems, including compartmental analysis and quantitation of organ radiotracer uptake.
- IV. Computer science
- Basic aspects of computer structure, function, and programming.
 - Principles of computer applications, with emphasis on digital image acquisition, image filters, quantitative analysis, processing and enhancement, tomographic reconstruction, and display and recording of findings.
 - Principles of data transport and storage, image transport, picture archiving, image fusion, and telecommunication systems.
 - Word processing, medical information systems, database technology, and spreadsheet analysis.
- V. Radiation biology and protection
- Biologic effects of radiation exposure, with emphasis on the effects of low-level exposure.
 - Administrative and technical means of reducing unnecessary radiation exposure to patients, personnel, the public, and the environment.
 - SI units (Système International d'Unités) and appropriate conversions.
 - Calculation of radiation dose from internally administered radionuclides.
 - Diagnosis, evaluation, clinical management, treatment, monitoring, decontamination, and subsequent control for patients experiencing radiation overexposure in any form.
 - Governmental regulations regarding limits of radiation exposure, handling of radioactive patients, and disposal of radioactive wastes.
 - Establishment of radiation safety programs in accordance with federal and state regulations.
- VI. Radiopharmaceutical production, biochemistry, and clinical physiology
- Production of radionuclides by reactors, cyclotrons, and other particle accelerators and the use of radionuclide generators.
 - Formulation and labeling of radiopharmaceuticals; quality control procedures, including sterility and pyrogenicity; and familiarity with good manufacturing practice.
 - Biochemistry, physiology, molecular biology, and pharmacokinetics of radiopharmaceuticals and mechanisms of localization in normal and abnormal physiologic states.
 - Role of regulatory bodies and regulations applicable to the use of radiopharmaceuticals in nuclear medicine practice and research.
- VII. In vivo diagnostic use of radiopharmaceuticals
- In vivo imaging or body function measurements of the central nervous system, endocrine system, salivary glands, bone marrow and hematologic system, respiratory system, cardiovascular system, gastrointestinal tract, hepatobiliary system, lymphatic system and spleen, musculoskeletal system, and genitourinary system and multiorgan oncologic imaging.
 - Use of imaging devices and detectors for body organ, time-dependent, and differential function studies and quantification of function, such as determination of tracer concentration in tissue, renal clearances, gastric emptying, gallbladder ejection fraction, and residual urine volume.
 - Cellular kinetics, absorption, excretion, and dilution analyses using radiotracers.
 - Nonimaging quantitative studies including the Schilling test, glomerular filtration rate, red cell mass, plasma volume, and breath tests for *Helicobacter pylori*, malabsorption, etc., and intraoperative use of scintillation detectors for lymph node identification.
 - Relationship between, and correlation of, nuclear medicine procedures and other pertinent imaging modalities including general radiology, mammography, angiography, ultrasonography, CT, MRI, and spectroscopy.
 - Relationship between, and correlation of, nuclear medicine procedures and other pertinent nonimaging studies such as thyroid function tests, renal function tests, blood glucose level, and carcinoembryonic antigen level.
 - Patient monitoring, with special emphasis on electrocardiographic interpretation and cardiopulmonary resuscitation during interventional tests such as exercise and pharmacologic stress and management of acute allergic reactions.
 - Pharmacology of drugs used in nuclear medicine.

- i. Applications of labeled antibodies, antibody fragments, peptides, metabolic substrates, and cells.
- j. Interventional studies in nuclear medicine, including pharmacologic interventions in cardiac, renal, cerebral, hepatobiliary, and ^{18}F -FDG imaging.
- k. Basic knowledge of cross-sectional anatomy.

VIII. Therapeutic uses of radionuclides

- a. Patient selection, including the diagnostic procedures necessary to establish the need for and safety of radionuclide therapy, the indications and contraindications for the use of radionuclide therapeutic procedures, and the effectiveness of these procedures in relation to other therapeutic approaches.
- b. Understanding and calculation of absorbed radiation dose, including calculation of absorbed radiation dose to the target area, to the surrounding tissue, to other organ systems, and to the total body.
- c. Patient care during radionuclide therapy, including understanding potential early and late adverse reactions, additive toxicity when combined with other therapy, the timing and parameters of anticipated response, and follow-up care and evaluation.
- d. Potential adverse effects of radiation, including oncogenesis and genetic effects, effects on family members and the public, maximum body dose on discharge from the hospital, and application to children (cancer incidence, tissue sensitivity).
- e. Specific therapeutic applications such as radioiodine in hyperthyroidism and thyroid carcinoma, radionuclides for the pain of metastatic bone disease, radiocolloids for therapy, radiolabeled antibody therapy, radiolabeled peptide therapy, and radiophosphorus (soluble) in polycythemia vera and other myeloproliferative disorders.

