Performance and Responsibility Guidelines for the Nuclear Medicine Technologist

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Objective: The skills of individual nuclear medicine technologists vary widely across the nation.
Methods: In order to ensure that technologists have the same knowledge base, the Socio-Economic Affairs Committee of the Technologist Section of the Society of Nuclear Medicine developed a set of guidelines compiled from various sources.
Results: As complete as the following guidelines may be, by the time they are published, they may be already partially obsolete in the ever-changing field of nuclear medicine technology.
Conclusions: These guidelines are not to be considered as rules that a technologist must adhere to, but rather as a checklist to enable the technologist to have a broader understanding of his or her profession.
Key Words: guidelines; NMTCB; nuclear medicine technologist; patient care; nuclear instrumentation; quality control; radiopharmaceuticals; radionuclide therapy; radiation safety

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The spectrum of nuclear medicine technology skills and responsibilities varies widely across the country. The broad description in this document is intended to provide a basis for determining the areas of knowledge and performance for the nuclear medicine technologist. The documents used in the revision and development of these guidelines were the Performance and Responsibility Guidelines for the Nuclear Medicine Technologist (*1*), Nuclear Medicine Technology Certification Board (NMTCB) Report: Equipment and Procedures in Current Practice (*2*), NMTCB Critical Task Analysis Report (*3*) and the Essentials and Guidelines for an Accredited Educational Program for the Nuclear Medicine Technologist (1991) (*4*).

These guidelines should be considered a helpful checklist of those skills necessary to perform a variety of nuclear medicine procedures. While the editors tried to be complete, nuclear medicine technology is a dynamic and evolving field; therefore, any list is likely to be partially obsolete as soon as it is issued. In addition, this document is not designed to be a "how to" description for any of the listed activities, nor is it intended to modify or alter existing tort law.

Nuclear medicine is the field of medicine that uses unsealed radioactive materials in the diagnosis and treatment of disease. This includes the administration of a radiopharmaceutical to a patient for the therapeutic treatment and/or the imaging of the radiopharmaceutical distribution in an organ or area of interest within the patient. The practice of nuclear medicine technology encompasses multidisciplinary skills. The responsibilities of the nuclear medicine technologist include an empathic and instructional approach to patient care, the preparation, calibration and administration of radiopharmaceuticals and pharmaceuticals (under the direction of an authorized user), the performance of quality control procedures and the operation of imaging, laboratory and computer instrumentation.

Continuing education is a necessary component in maintaining the skills required to perform the duties and tasks of a nuclear medicine technologist.

In order to perform these tasks, the nuclear medicine technologist must successfully complete didactic and clinical training. Recommended course work includes but is not limited to: anatomy, physiology, pathophysiology, chemistry, physics, mathematics, computer applications, biomedical sciences and radiation science health and safety. Direct patient contact hours are obtained by training in a clinical setting.

Formal education programs in nuclear medicine technology are accredited by the Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRC-NMT). Graduates of accredited programs are eligible to take the certification examination offered by the Nuclear Medicine Technology Certification Board (NMTCB) and/or the American Registry of Radiologic Technologists (ARRT).

The scope of performance in nuclear medicine technology includes, but is not limited to the following areas and responsibilities:

Patient care: Requires the exercise of judgment to assess and respond to patient's needs prior to, during and after visits in the nuclear medicine department.
Quality control: Requires the evaluation and maintenance of a quality control program for instrumentation to ensure its credibility and reliability.

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Diagnostic procedures: Requires the utilization of an appropriate technique to ensure quality diagnostic images and/or laboratory results.

Radiopharmaceuticals: Involves the procurement, preparation, quality control, calculation, identification, documentation, administration, disposal, storage and safe handling of such materials.

Radionuclide therapy: Assists an authorized user in the application and management of a therapeutic radionuclide treatment.

Radiation safety: Educates the public and uses techniques that will minimize radiation exposure to the patient, general public, and health care personnel consistent with the ALARA (as low as is reasonably achievable) concept.

I. Patient Care

A. A nuclear medicine technologist provides patient care by:
   1. Providing for proper comfort and care to the patient prior to, during and after a procedure;
   2. Establishing and maintaining good communication with patients (i.e., introducing themselves, explaining the procedures, answering questions);
   3. Providing functionally safe and sanitary conditions for the patient in compliance with universal protection policies; and
   4. Recognizing and responding to an emergency condition by:
      a. initiating a call for assistance;
      b. monitoring and recording physiologic data (i.e., ECG, pulse rate, respiratory rate);
      c. administering cardiopulmonary resuscitation when necessary; and
      d. maintaining intravenous fluids, oxygen and other life-support assistance until an emergency code team arrives.

B. A nuclear medicine technologist prepares the patient by:
   1. Verifying patient identification, last menstrual period and written orders for the procedure;
   2. Checking for contraindications and obtaining a pertinent history;
   3. Assuring informed consent has been obtained when necessary;
   4. Explaining the procedure to the patient;
   5. Checking patient clothing and linen for objects that may cause artifacts in the images; and
   6. Waiting an appropriate length of time after the administration of a radiopharmaceutical to begin the procedure.

C. A nuclear medicine technologist performs administrative procedures by:
   1. Maintaining an adequate volume of medical/surgical supplies, radiopharmaceuticals and film to ensure that a patient procedure may be performed whenever necessary;
   2. Scheduling patient procedures with timely arrangements;
   3. Determining the appropriate sequence for multiple procedure requests;
   4. Maintaining appropriate records of patient doses, quality control procedures, patient reports and other required records;
   5. Revising and developing recordable procedure guidelines in collaboration with an authorized user; and
   6. Participating in the quality assurance program.

II. Nuclear Instrumentation: Quality Control

A. A nuclear medicine technologist evaluates the performance of scintillation cameras by:
   1. Obtaining uniformity images:
      a. Selecting a radionuclide source of appropriate type, size, (if necessary), quantity and energy.
      b. Selecting an appropriate pulse-height analyzer (PHA) photopeak and window.
      c. Obtaining uniformity images using standardized imaging parameters.
      d. Evaluating the images qualitatively, and if possible quantitatively in comparison to the manufacturer's specifications.
      e. Identifying the source of any nonuniformity (i.e., checking collimator, PHA peak setting).
      f. Initiating correction action when necessary.
   2. Performing a detector linearity evaluation:
      a. Selecting a radionuclide, a linearity phantom and obtaining images.
      b. Identifying any nonlinear distortion in the image.
      c. Determining the source of nonlinearity (i.e., detector-source geometry).
      d. Initiating corrective action when necessary.
   3. Performing spatial resolution checks:
      a. Selecting an appropriate radionuclide.
      b. Choosing a phantom that is compatible with the specified resolution of the camera.
      c. Analyzing the resulting images for resolution degradation.
      d. Initiating corrective action when necessary.
   4. Conducting sensitivity checks:
      a. Selecting a source with an appropriate level of activity and half-life.
      b. Assuring identical geometry, source placement and measurement parameters for repetitive checks.
   5. Performing SPECT quality control procedures:
      a. Obtaining a high-count uniformity flood.
      b. Obtaining a center of rotation correction.
      c. Verifying energy correction and spatial coordinates.

d. Verifying multihead detector alignment.
e. Evaluating reconstruction results of a phantom acquisition.
f. Analyzing the results for degradation.
g. Initiating corrective action when necessary.

6. Checking computer parameter settings and data interface:
   a. Assuring camera and computer register same count rate at max frame rate.
   b. Verifying the camera and computer have the same image orientation.
   c. Obtaining a dead time measurement on the computer.
   d. Verifying accuracy of ECG gating.
7. Checking the analog and/or digital recording device(s):
   a. Performing a lens focus check (i.e., CRT).
   b. Checking and adjusting imaging device for contrast and brightness (i.e., densitometry).
   c. Assessing integrity of imaging device.
   d. Maintaining cleanliness of all equipment (i.e., lens, fan covers).
8. Maintaining the required records for the quality control program.

B. A nuclear medicine technologist evaluates the performance of NaI(Tl) scintillation probes and well counters by:
1. Calibrating a spectrometer with a calibrated long half-life radionuclide source;
2. Determining energy resolution;
3. Conducting sensitivity measurements at appropriate energies;
4. Checking background and determining the cause for levels greater than established normal levels;
5. Conducting a chi-square test; and
6. Maintaining required records for quality control programs.

C. A nuclear medicine technologist operates survey meters by:
1. Ensuring calibration is completed with an approved agent;
2. Performing a reference check-source test and comparing with previous results;
3. Maintaining required records for quality control program.

D. A nuclear medicine technologist evaluates the operation of a dose calibrator by:
1. Verifying the calibration;
2. Ascertaining linearity over the entire range of radionuclide activity to be measured; and
3. Testing for significant geometric variation in activity measured as a function of sample volume or configuration and determining correction factors.

E. A nuclear medicine technologist operates and maintains film processors by:
1. Monitoring and recording sensitometry and temperature of water and dryer daily and
2. Maintaining required records for quality control program.

III. Diagnostic Procedures

A. A nuclear medicine technologist performs imaging procedures by:
1. Selecting imaging parameters:
   a. Selecting and preparing the instrument for the procedure.
   b. Selecting appropriate parameters for digital and/or analog acquisition.
   c. Recognizing artifacts that are due to instrumentation malfunction and initiating appropriate action.
2. Administrating radiopharmaceuticals and/or pharmaceuticals using universal precaution techniques:
   a. Verifying patient identity prior to the administration of medication or radiopharmaceuticals.
   b. Determining route of administration according to established protocol (i.e., subcutaneous, intramuscular, intravenous, etc.).
   c. Establishing and/or verifying venipuncture access using aseptic technique.
   d. Using and maintaining established venous access routes (i.e., heparin infusion, IMED).
   e. Establishing patterned breathing when introducing radiopharmaceuticals (i.e., inhalants or aerosols).
   f. Administering oral radiopharmaceuticals.
   g. Documenting medications and/or radiopharmaceutical administration on a patient's permanent medical record.
3. Positioning the patient and obtaining images:
   a. Performing imaging views according to established protocols and acquiring additional views to optimize information content.
   b. Placing the patient in correct position using supportive materials and immobilizer as necessary.
   c. Exercising independent judgment in positioning a patient or detector unit to best demonstrate pathology.
   d. Indicating appropriate anatomic landmarks for each view of the procedure.
   e. Reviewing images to assure that correct information is supplied.
4. Assisting the physician in cardiac stress testing when performed in conjunction with nuclear medicine procedures:
   a. Preparing patient's skin and placing ECG leads appropriately.
   b. Recognizing and being responsive to any changes that may occur on either a resting or stress ECG.

c. Recognizing the parameters that should terminate a cardiac stress study.

5. Performing data collection, processing and analysis:
   a. Performing data collection, processing and analysis in accordance with established protocols.
   b. Exercising independent judgment in selecting appropriate images for processing.
   c. Selecting appropriate filtering, frequency cutoff and attenuation correction when reconstructing SPECT images.
   d. Defining regions of interest (ROIs) with reproducible results and correctly applying background subtraction.
   e. Performing time-activity curve generation and additional manipulation (i.e., $T_{1/2}$).
   f. Labeling processed images to reflect anatomical positioning, ROIs, etc.
   g. Preserving and retrieving data from storage media.

B. A nuclear medicine technologist performs nonimaging in vivo and/or radioassay studies by:
   1. Operating laboratory equipment:
      a. Checking accuracy, precision and operation of pipetting device.
      b. Using microhematocrit centrifuge and determining hematocrit.
   2. By preparing doses and guidelines:
      a. Quantitating dose by:
         1. determining decay factor and calculating remaining activity;
         2. determining volume necessary to deliver activity for the prescribed dose;
         3. drawing dose into syringe using appropriate techniques and materials;
         4. dispensing appropriate quantity of liquid or capsules, as necessary, for the prescribed dose; and
         5. confirming calculated activity by using a dose calibrator.
      b. Preparing standard by:
         1. choosing appropriate volumetric or gravimetric techniques to dilute standard;
         2. adding radioactive material identical to that given the patient q.s. (quantity sufficient) to appropriate volume; and
         3. diluting capsule in appropriate solvent, if necessary, for preparing a standard.
   3. By collecting proper specimen for procedures using universal precaution techniques:
      a. Collecting blood samples by:
         1. selecting proper supplies (i.e., needles, syringes, evacuated tubes, anticoagulants, etc.);
         2. labeling patient demographics on collection containers;
         3. performing venipuncture at appropriate time intervals using aseptic technique;
         4. adding hemolyzing compounds to samples when necessary;
         5. centrifuging blood and separating blood components as required; and
         6. storing aliquot of serum, plasma, or whole blood according to protocol.
      b. Collecting urine samples by:
         1. instructing patient and nursing staff as to correct method and time of urine collection
         2. aliquoting urine sample and measuring total urine volume
         3. measuring specific gravity of urine, if required
         4. recognizing and documenting all technical circumstances which would produce invalid results
   4. Performing calculations:
      a. subtracting room or patient background from appropriate samples;
      b. applying appropriate formulas, including conversion and dilution factors;
      c. calculating results according to procedure used;
      d. plotting graph, if necessary, and determining half-time by extrapolating to zero time; and
      e. reporting both patient calculated values and normal range of specific procedures used.
   5. Managing biohazardous waste using disposal methods adopted as facility policy.

IV. Radiopharmaceuticals

A. A nuclear medicine technologist initiates purchase of radiopharmaceutical products and adjunct supplies by:
   1. Anticipating and procuring a sufficient supply of radioactive drugs for an appropriate time period in accordance with anticipated need and license possession limits;
   2. Storing drugs and supplies in a manner consistent with labeled product safeguards and with radiation safety considerations;
   3. Performing and documenting radiation wipe tests upon receipt of radioactive materials;
   4. Recording receipt of radioactive materials in a permanent record; and
   5. Following DOT and radiation safety guidelines in the transport, receipt and shipment of radioactivity.

B. A nuclear medicine technologist prepares and verifies quality of radiopharmaceuticals under the direction of an authorized user by:
   1. Employing aseptic technique for manipulation of injectable products;
   2. Assembling and maintaining radionuclide generators;

3. Eluting radionuclide generators according to manufacturers specification;
4. Verifying radionuclide purity of generator eluates;
5. Selecting and preparing radiopharmaceuticals in accordance with manufacturers specifications;
6. Measuring and calculating activity of the radionuclide with a dose calibrator;
7. Confirming the quality of a radiopharmaceutical in accordance with accepted techniques and official guidelines;
8. Preparing labeled blood cells (i.e., ^{111}In-WBC) in accordance with established protocols; and
9. Recording use and/or disposition of all radioactive materials in a permanent record.

C. A nuclear medicine technologist is responsible for the identification and labeling of all radiopharmaceutical preparations by:
1. Labeling the container with the radiopharmaceutical, hour, date and expiration time and radiation symbol;
2. Recording radiopharmaceutical and medication information on a patient's administration form and permanent preparation records; and
3. Labeling and segregating radioactive waste and recording this information in a permanent record.

D. A nuclear medicine technologist prepares individual dosages under the direction of an authorized user by:
1. Applying radioactive decay calculations to determine required volume or unit form necessary to deliver the prescribed radioactive dose;
2. Selecting and preparing prescribed dosages and entering this information on a patient's administration form and other permanent records;
3. Labeling the dose for administration; and
4. Checking the dose activity prior to administration in a dose calibrator and comparing this measurement against the identification label of the dose's immediate container.

V. Radionuclide Therapy

A. Nuclear medicine technologist assists an authorized user in the preparation and applications of therapeutic radionuclides by:
1. Assuring the correct radiopharmaceutical and dosage is prepared;
2. Having the authorized user and the technologist verify the dose;
3. Assuring the patient is correctly identified by the technologist and authorized user according to the quality management program in effect at the particular institution;
4. Preparing and/or coordinating environmental preparations (i.e., decontamination supplies);
5. Observing prescribed radiation safety procedures during the preparation and the administration of such treatment;
6. Assisting the authorized user in supplying proper patient care instructions to hospital staff, patient, and/or caregivers;
7. Conducting and documenting radiation surveys of designated patient areas, when indicated; and
8. Supplying hospital staff, patient and/or caregivers with proper instructions on handling and disposal of all contaminated supplies when necessary.

VI. Radiation Safety

A. A nuclear medicine technologist under supervision of an authorized user or radiation safety officer maintains compliance with local, state or federal regulations in radiation safety practices by:
1. Notifying appropriate authority when changes occur in the radiation safety program;
2. Assisting in the preparation of license amendments, when necessary;
3. Periodically reviewing and complying with regulations;
4. Maintaining required records;
5. Posting appropriate signs in designated areas;
6. Following regulations regarding receipt and disposition of all radionuclides;
7. Carrying out a program to follow regulations regarding therapeutic doses and follow-up;
8. Recommending purchase of protection equipment to meet regulations; and
9. Packaging radioactive material according to regulations and keeping accurate records of transfer.

B. A nuclear medicine technologist follows appropriate protection procedures by:
1. Using personnel-monitoring devices (i.e., dosimeters, film badges, TLDs, etc.)
   a. Reviewing monthly personnel exposure records in regard to maximum permissible dose limits;
   b. taking appropriate measures to reduce exposure when necessary; and
   c. notifying proper authorities of excessive exposure upon occurrence.
2. Selecting and using proper shielding to reduce radiation exposure;
3. Using proper methods for storage and disposal of radioactive materials;
4. Identifying and using proper procedures for those radionuclides that pose special hazards (i.e., ^{89}Sr, ^{131}I); and
5. Performing a bioassay on a technologist as per state and/or federal regulations.

C. A nuclear medicine technologist performs surveys by:

1. Ensuring that instruments are calibrated at regular intervals, or after repairing according to regulations;
2. Setting frequency and locations for surveys and following schedules;
3. Using appropriate survey meters for each type and level of activity;
4. Following regulations regarding personnel surveys and reporting to the designated physician or radiation safety officer;
5. Performing constancy checks on survey meters;
6. Performing wipe tests where applicable;
7. Performing leak tests on sealed sources when so authorized; and
8. Recording data in standard format.

D. A nuclear medicine technologist performs decontamination procedures by:
1. Wearing appropriate clothing and foot covering as necessary;
2. Block access to area and confining a spill;
3. Removing contamination or reducing the activity to acceptable levels;
4. Monitoring the area and personnel and repeating decontamination procedure until activity levels are acceptable;
5. Closing off all areas of fixed contamination that are above acceptable levels;
6. Identifying, storing or disposing of contaminated material in accordance with regulations;
7. Maintaining adequate records concerning clean-up; and
8. Notifying appropriate authority (i.e., radiation safety officer) in the event of possible overexposure or other violations of regulations.

E. A nuclear medicine technologist disposes of radioactive waste by:
1. Maintaining appropriate records and
2. Disposing of waste properly according to license specifications.

F. A nuclear medicine technologist participates in a hospital's in-service program to instruct other personnel about radiation hazards and principles of radiation safety by:
1. Teaching concepts:
   a. Types of ionizing radiation;
   b. The biological effects of ionizing radiation;
   c. Limits of dose, exposure and radiation effect;
   d. Concepts of low-level radiation and health; and
   e. Concept of risk versus benefit.
2. Providing instruction on appropriate radiation safety measures
3. Providing instruction on proper emergency procedures to be followed until radiation safety personnel arrive at the site of accident or spill.

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