Task Analysis

NMTCB Task Analysis of Nuclear Medicine Technology

The Nuclear Medicine Technology Certification Board

Job relatedness is the basis upon which the Nuclear Medicine Technology Certification Board developed its entry-level competence examination. In order to ensure job relatedness, this task analysis was derived by the Board with input from practicing technologists across the country. It is intended as a broad outline of the tasks that are performed in the clinical setting by a competent technologist. The examination content is based upon the tasks enumerated and the implied skill and knowledge necessary to perform those tasks. This task analysis will constantly evolve as the field of nuclear medicine continues to change. As new technologies are incorporated into routine practice, the task analysis will be modified to reflect those changes. The NMTCB always welcomes comment and input regarding the task analysis. Comments should be forwarded to the NMTCB office in Stone Mountain, GA.

I. NUCLEAR INSTRUMENTATION—QUALITY CONTROL

A. Perform routine imaging system evaluations:

1. Scintillation cameras—

a. Perform field uniformity check–

1) select radionuclide source of appropriate quantity and energy;

2) check pulse height analyzer photopeak adjustment;

3) obtain uniformity images using identical standardized imaging parameters, i.e., counts, information density (I.D.), intensity, etc.

b. Analyze field uniformity images–

1) compare with previous uniformity image and identify any nonuniformities:

2) differentiate source of nonuniformities using proper procedures, i.e., check collimator, pulse height analyzer (PHA) peaking, detector, cathode ray tube (CRT), lenses;

3) obtain service if indicated.

c. Perform detector linearity check–

1) place source for uniformity check and a parallel line phantom in proper position;

2) obtain two images orientated 90° to each other using standardized imaging parameters;

3) identify any line distortion on the image;

4) determine the source of nonlinearity, i.e., camera system, components, detector-source geometry, and arrange for service if nonlinearity is present.

d. Perform spatial resolution checks–

1) use uniformity check source;

2) utilize a high resolution phantom compatible with the specified resolution of the camera;

3) obtain resolution images oriented 90° to each other using standardized imaging parameters;

4) compare with prior resolution images;

5) obtain service if resolution degradation is observed.

e. Conduct sensitivity checks–

1) position source with an appropriate half-life;

2) assure that identical geometry and measurement parameters are used each time.

f. Check image recording equipment–

1) perform lens focus check;

2) check and adjust CRT dot focus and shape;

3) assess integrity of CRT phosphor.

g. Maintain the required records for quality control checks.

2. Rectilinear scanners—

a. Assess performance of NaI(Tl) scintillation spectrometer–

1) calibrate with Cs-137;

2) determine percent FWHM energy resolution;

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3) conduct a sensitivity check;
4) perform a 60-cycle test count if available.

b. Check calibration of photorecorder–
1) compare three film exposures taken at three information densities for equal film density;
2) assess operation of contrast enhancement and background erase using a transmission gray wedge;
3) compare results with previous results to determine any changes in system operation;

c. Maintain required records of the quality control procedures.

B. Scintillation counters:

1. Calibrate with Cs-137.
2. Determine percent FWHM energy resolution.
3. Conduct sensitivity checks.
4. Check background and determine cause for higher-than-normal background.
5. Take a 60-cycle test count if possible.
6. Conduct a chi-square evaluation.
7. Perform an energy linearity check at installation.
8. Perform volumetric calibration at time of installation.
9. Maintain records of these procedures as required.

C. Gas-filled detectors:

1. Survey meters (G-M tubes)—

a. calibrate according to NRC specifications;
b. perform reference check-source test and compare with previous results;
c. maintain records as required.

2. Dose calibrator (ionization chamber)—

a. ascertain linearity over entire range of radionuclide activity to be measured;
b. test for significant geometrical variation in activity measured as a function of sample volume or configuration and determine correction factors;
c. test accuracy for commonly used radionuclides that have adequate reference standards available;
d. check for constancy using a long-lived radionuclide standard;
e. maintain records of the procedures as required.

II. DOSE CALCULATION AND ADMINISTRATION

A. Dispense radiopharmaceuticals:

1. Quantitate exact dose—

a. verify label on radiopharmaceutical vial including concentration, specific activity, total activity, lot number, assay time, and date;
b. determine actual elapsed time between assay calibration and required dose calculation time;
c. calculate activity remaining using the appropriate decay factor for the time elapsed;
d. calculate activity needed for procedure;
e. determine volume of the radiopharmaceutical required for patient dose.

2. Prepare dose of radioactivity—

a. dispense liquid preparation–
1) draw up correct volume of the radiopharmaceutical into a syringe using aseptic technique and observing proper radiation safety precautions;
2) verify the dose of radioactivity using a dose calibrator;
3) record patient name, examination, activity, volume, lot number, time, date, and prescription number, if appropriate.

b. dispense gaseous preparation–
1) calibrate and dispense radioactive gas from bulk load system or unit dose system;
2) load radioactive gas into administration machine if appropriate;
3) maintain appropriate records.

B. Administer dose of radiopharmaceutical:

1. assemble the proper materials for venipuncture;
2. determine proper method and route of administration;
3. evaluate patient's venous anatomy and determine a suitable site for venipuncture;
4. reassure the patient and try to relieve any apprehension;
5. disinfect the site of puncture;
6. administer dose with proper venipuncture techniques;
7. observe patient for possible reactions;
8. discard radioactive materials in appropriate waste containers.

III. IMAGING PROCEDURES

A. Provide patient care:

1. Receive patient and provide for proper nursing care during imaging procedure.
2. Provide for patient comfort, before, during, and after the procedure.
3. Maintain good communication with patient, explain procedure, answer questions, and listen to patient's comments.
4. Provide functionally safe and sanitary conditions for patient.

5. Recognize emergency conditions—
   a. determine "vital signs" when necessary, including pulse rate, respiratory rate, temperature, and blood pressure;
   b. administer cardiopulmonary resuscitation when necessary;
   c. maintain intravenous fluids, oxygen, and other life-support equipment.

B. Prepare patient:

1. Verify patient identification and written orders for study.
2. Check for contraindications and obtain pertinent history.
3. Obtain formal consent when necessary.
4. Check patient clothing and linen for objects (scars, inflammed areas, etc.) that may attenuate and contaminate.
5. Prepare patient with premedications (Lugol's, perchlorate), instruct patient to void, etc., include any preparation necessary for the imaging procedure required.
6. Wait appropriate length of time after administration of radiopharmaceutical to begin imaging procedure.

C. Perform imaging procedures:

1. *Select imaging parameters—*
   a. select proper instrument and auxiliary equipment necessary to perform imaging procedure;
   b. prepare instrument for procedure, i.e., select proper collimator, imaging parameters, setting, etc.;
   c. select appropriate parameters for data acquisition using a computer;
   d. recognize artifacts that are due to instrument malfunction.
2. *Position patient and obtain images—*
   a. select required positions for procedure;
   b. place patient in correct position using supportive materials and immobilizers to obtain scintigrams for each view;
   c. determine correct detector-to-patient distance;
   d. indicate appropriate anatomical landmarks for each view of a procedure.
3. *Perform data processing—*
   a. perform any necessary data manipulations to achieve desired end product of imaging procedure;
   b. process film according to manufacturers specifications and film processor optimum operation;
   c. review study to assure correct information is supplied and any special views required have been obtained;
   d. analyze data acquired and report results to physicians for interpretation;
   e. maintain quality control for all aspects of the imaging procedure.

D. Perform administrative procedures:

1. Maintain adequate supplies of radiopharmaceuticals and all other materials including film to ensure that patient studies may be performed whenever necessary.
2. Schedule patient studies, ensuring that appropriate study is scheduled. Interact with hospital staff to effect proper and timely arrangements for patient study.
3. Determine the most appropriate sequence for multiple procedures.
4. Maintain appropriate records of patient doses, quality control procedures, patient reports, and other required records.
5. Maintain procedure manual and update manual on a regular periodic basis.

Note: Apply the aforementioned tasks for the following types of procedures: central nervous system, endocrine, cardiopulmonary, genitourinary, gastrointestinal, and hematologic.

IV. RADIOPHARMACY

A. Maintain radiopharmaceutical laboratory:

1. Initiate purchase orders for supplies of radiopharmaceuticals and other supplies.
2. Perform "wipe tests" of the exterior package on all radioactive shipments received.
3. Log in the receipt of radioactive materials in a record book.
4. Monitor all packaging materials and deface radiation symbols on boxes before discarding.
5. Store radioactive materials and nonradioactive kits in the appropriate area.
6. Determine necessity to reorder radiopharmaceuticals and kits to prevent delays.

B. Obtain generator eluate:

1. Assemble generator and position behind lead barriers.
2. Elute generator using aseptic technique.
3. Assay the eluate using a dose calibrator or whole-vial assay.
4. Record the assay results and time in a log book.
5. Check the eluate for radionuclidic and chemical contamination and record results.

C. Compound radiopharmaceuticals:

1. Review daily work schedule and prepare appropriate radiopharmaceutical compounds using [^{99m}Tc] pertechnetate to include sulfur colloid, microspheres or macroaggregated albumin, phosphates, DTPA, etc.
2. Determine the amount of radioactivity to be added to a radiopharmaceutical kit and record the volume of generator eluate used. Be aware of any activity limits in preparation of kits.
3. Prepare radiopharmaceutical assay form for each lot of material.
4. Check total activity in reaction vials in dose calibrator.
5. Calculate the concentration of radioactivity of the compound and label vial as to the date and time of preparation, lot number, the concentration and the volume.
6. Check all preparations for proper pH, color, clarity, and particle size if appropriate and record on radiopharmaceutical assay form.
7. Determine the radiochemical purity of the compound by chromatography or electrophoresis.

D. Dispose of radioactive waste:

1. Monitor all radioactive dose vials and determine if acceptable to discard.
2. Monitor alumina columns from generators to determine if acceptable to discard.
3. Maintain long-term storage area to allow for decay of radioactivity.
4. Maintain log on radiopharmaceutical disposal.

V. RADIATION PROTECTION

A. Maintain local state or federal license and assure compliance with regulations:

1. Notify appropriate authority when change in safety program occurs.
2. Amend license when necessary.
3. Review regulations periodically.
4. Maintain required records.
5. Post appropriate signs in designated areas.
6. Design program to follow regulations regarding the receipt and disposition of all radionuclides.
7. Design and carry out program to follow regulations regarding therapeutic doses and follow up.
8. Recommend purchase of any protection equipment to meet regulations.
9. Package radioactive material according to regulations and keep accurate records of transfer.

B. Follow appropriate protection procedures:

1. Employ personnel monitoring devices—

a. review monthly personnel exposure records in regard to maximum permissable dose limits;
b. take appropriate measures to reduce exposure when necessary;
c. keep exposure as low as is reasonably achievable using appropriate protection parameters continuously;
d. notify the NRC of excessive exposure when appropriate.

2. Select and use proper shielding to reduce radiation exposure, i.e., employ inverse square law and half-value layers.
3. Use proper methods for the storage of radioactive materials.
4. Identify and use proper procedures for those radionuclides which pose special hazards.

C. Surveys:

1. Calibrate survey instruments.
2. Set frequency and locations for surveys and follow schedule.
3. Use proper survey meters for each type and level of activity.
4. Follow regulations regarding personnel surveys and interpret results.
5. Perform wipe tests where applicable.
6. Perform leak tests on sealed sources when appropriate.
7. Record data in some standard format.

D. Perform decontamination procedures:

1. Block access to area and confine the spill.
2. Remove contamination or reduce the activity to acceptable levels.
3. Monitor the area and personnel and repeat decontamination procedure until levels of activity are acceptable.
4. Store and dispose of contaminated material following regulations.
5. Maintain adequate records concerning the clean up.

E. Dispose of radioactive waste:

1. Maintain appropriate records.
2. Dispose of waste properly according to license specifications.

F. Participate in inservice program to instruct other personnel about radiation hazards and principles of radiation safety:

1. Teach concepts including—

a. the biological effects of ionizing radiation;
b. limits of dose, exposure and radiation effect;
c. types of ionizing radiation.

2. Provide instruction on appropriate radiation safety measures.
3. Provide instruction on proper emergency procedures to be followed until radiation personnel arrive at the site of accident or spill.

VI. NONIMAGING PROCEDURES

A. In vivo:

1. Operate laboratory equipment—

a. Check accuracy and operation of pipetting devices.

b. Use microhematocrit centrifuge and determine hematocrit.

c. Compute relative centrifugal force, operate centrifuges, and maintain routine tachometer checks.

d. Maintain refrigerator for storage of reagents and standards.

e. Maintain quality control records on all laboratory equipment.

2. Prepare doses and standards—

a. Quantitate exact dose-

1) determine decay constant and calculate remaining activity;

2) determine volume necessary to deliver required activity;

3) draw dose into syringe using appropriate materials;

4) confirm calculated activity by using a dose calibrator.

b. Prepare standard-

1) choose appropriate volumetric glassware for dilution of the standard;

2) add a portion of solvent to glassware and a solution to prevent sticking;

3) add a dose similar to that given the patient and dilute up to calibration mark;

4) dilute capsule in appropriate solvent if necessary for a standard.

3. Collect proper specimen for procedure—

a. Blood collection-

1) select proper equipment for blood collection (needles, syringes, anticoagulants, etc.);

2) perform venipuncture at appropriate time intervals;

3) add hemolyzing compounds when necessary;

4) centrifuge blood and separate blood components;

5) store aliquot of serum, plasma, or whole blood according to protocol.

b. Urine collection-

1) choose appropriate container for urine collection;

2) add a small amount of preservative to container;

3) instruct patient and nursing staff about the method and length of urine collection;

4) aliquot urine sample and measure total urine volume;

5) measure specific gravity of urine if required;

6) collect additional urine if volume collected is insufficient.

c. Stool collection-

1) choose appropriate container for stool collection;

2) instruct both patient and nursing staff as to correct method of stool collection;

3) homogenize stool and aliquot sample for counting; or

4) place sample of stool in carton for counting, maintaining same geometry.

4. Operate counting equipment—

a. Set pulse height analyzer on scintillation detector and center the photopeak within the analyzer settings chosen for the procedure.

b. Count in vitro samples, standards, and room background for a statistically significant number of counts, making corrections for geometrical differences if necessary.

c. Outline organs to be counted externally and count for a statistically significant number of counts.

d. Choose correct detector-patient distance.

5. Perform calculations—

a. Subtract room background or patient background from all samples.

b. Apply appropriate formulas, including conversion and dilution factors.

c. Calculate results according to the procedure employed.

d. Plot graph if necessary and determine $T^1/_2$ or extrapolate to zero time.

e. Calculate organ ratios.

f. Report both patient calculated values and the normal range of the specific procedure used.

Apply these tasks to the following procedures where applicable: blood volumes (Cr-51 and RISA), red cell survivals, ferrokinetic studies, gastrointestinal protein loss, gastrointestinal blood loss, thyroid uptakes, and Schilling test.

B. In vitro:

1. Operate laboratory equipment—

a. Check accuracy and operation of all pipetting devices used.

b. Maintain constant temperatures in water baths.

c. Compute relative centrifugal force, operate centrifuge and maintain routine tachometer checks.

d. Calibrate and operate pH meters.
e. Calibrate and use laboratory scales and balances.
f. Operate vortex mixers and shakers maintaining constant conditions.

2. *Collect blood sample—*
   a. Select proper equipment for blood collection (needles, syringes, etc.)
   b. Choose proper anticoagulant for specific procedure.
   c. Perform venipuncture at appropriate time intervals.
   d. Collect blood sample on ice as required.
   e. Centrifuge blood and separate blood components.
   f. Store aliquot of patient sample as dictated by the protocol.

3. *Perform assay—*
   a. Allow assay components and patient specimens to equilibrate to room temperature as required.
   b. Prepare assay reagents.
   c. Add RIA components according to the protocol.
   d. Incubate standards and samples in the appropriate environment for the required time.
   e. Separate the bound from the free radioactivity using the necessary laboratory equipment.
   f. Load samples in counter and set instrument counting.
   g. Count all samples for the appropriate time to give a statistically significant number of counts.
   h. Reduce data to net counts by subtracting room background and nonspecific binding counts.
   i. Calculate the desired fraction (bound/total, bound/free, free/total, etc.) for generation of the standard curve.
   j. Plot above fractions obtained for the standards on the appropriate graph paper.
   k. Determine data for all patient and controls from the derived standard curve.
   l. Transfer assay results to laboratory data record and to patient's request form.

4. *Quality control—*
   a. Develop and maintain quality control procedures for all assays, using appropriate control sera.
   b. Record daily results of all controls on quality control charts.
   c. Perform periodically the appropriate control sera checks.
   d. Maintain records of antibody binding for each assay to note any reagent deterioration.
   e. Recognize a significant shift in assay control and take appropriate action.
   f. Compare another laboratory's results with your own.

5. *Assay evaluation—*
   a. Perform all tasks necessary to assess the accuracy, precision, sensitivity, and specificity of the assay.
   b. Develop a normal range for each assay.
   c. Test for the biological validity of the assay.

6. *Kit evaluation—*
   a. Determine intra-assay and interassay variability.
   b. Determine assay accuracy by performing recovery studies.
   c. Choose kit with the best overall performance.