

The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

2015 (Resolution 53)*

ACR–AAPM PRACTICE PARAMETER FOR REFERENCE LEVELS AND ACHIEVABLE ADMINISTERED ACTIVITY FOR NUCLEAR MEDICINE AND MOLECULAR IMAGING

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care¹. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable

¹ *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing*, ___ N.W.2d ___ (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, *Stanley v. McCarver*, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of this document is to assist practitioners in achieving this objective.

I. INTRODUCTION

This practice parameter has been developed collaboratively by the American College of Radiology (ACR) and the American Association of Physicists in Medicine (AAPM) to guide appropriately trained and licensed physicians and Qualified Medical Physicists involved in nuclear medicine and molecular imaging procedures. The establishment of reference levels (RLs) in nuclear medicine and molecular imaging requires close cooperation and communication between the physicians responsible for the clinical management of the patient and the Qualified Medical Physicist responsible for monitoring equipment and image quality and estimating patient dose. Adherence to this practice parameter should help to maximize the efficacious use of these procedures, minimize radiation dose to patients and staff, maintain safe conditions, and ensure compliance with applicable standards. This is particularly important for children who are more vulnerable than adults to the potential risks of ionizing radiation.

The goal of this practice parameter is to provide guidance to physicians and Qualified Medical Physicists on the establishment and implementation of RLs in the practice of nuclear medicine and molecular imaging. The goal in medical imaging is to obtain image quality consistent with the medical imaging task. Reference levels are used to help manage the radiation dose to the patient. The medical radiation exposure must be optimized, avoiding unnecessary radiation that does not contribute to the clinical objective of the procedure. By the same token, an administered activity significantly lower than the achievable administered activity (AAA) may also be cause for concern, since it may indicate that adequate image quality is not being achieved. The specific purpose of the RL is to provide a benchmark for comparison, not to establish regulatory limits.

Reference levels for nuclear medicine and molecular imaging should be based on administered activity or dosage². There are published surveys and guidelines of administered activity from various professional organizations that can be used to establish RLs [1-13].

II. DEFINITION

A RL in nuclear medicine is an investigational (action) level that identifies higher than typical administered activities for routine nuclear medicine and molecular imaging procedures [14-16]. A procedure RL is set at approximately the 75th percentile of the range of available administered activity data. If a facility or practice consistently exceeds an RL, it should review its procedures and equipment to determine if acceptable image quality can be achieved with a lower administered activity.

Achievable administered activity is a concept that can be used with RLs to assist in optimization of image quality and dose. Although no formal system exists for determining AAA, the concept is based on the median administered activity in that 50% of facilities are producing images below that administered activity. Achievable administered activity for nuclear medicine and molecular imaging are set at approximately the 50th percentile of the range of administered activities. The AAA provides a goal that facilities should strive to achieve through the optimization of image quality and patient absorbed doses. Further information on RLs and AAAs in nuclear medicine and molecular imaging is available in the National Council on Radiation Protection and Measurements (NCRP) Report 172 [17].

² Dosage is the term used by the U.S. Nuclear Commission and other agencies that regulate radioactive materials to describe the patient administered activity and differentiate it from absorbed dose.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. Physician

See the [ACR–SNM Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#) [1].

B. Qualified Medical Physicist

A Qualified Medical Physicist is an individual who is competent to practice independently in one or more of the subfields in medical physics. The American College of Radiology (ACR) considers certification, continuing education, and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice one or more of the subfields in medical physics, and to be a Qualified Medical Physicist. The ACR strongly recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physicists in Medicine, or the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#). (ACR Resolution 17, adopted in 1996 – revised in 2012, Resolution 42). [18]

The appropriate subfields of medical physics for this practice parameter is Nuclear Medical Physics (including medical physics certification categories of Radiological Physics, Medical Nuclear Physics, and Nuclear Medicine Physics).

Certification by the American Board of Science in Nuclear Medicine in Nuclear Medicine Physics and Instrumentation is also acceptable.

The Qualified Medical Physicist must be familiar with the principles of imaging physics and radiation protection; the guidelines of the NCRP; the laws and regulations pertaining to nuclear medicine; the function, clinical uses, and performance specifications of nuclear medicine imaging equipment; and calibration processes and limitations of the equipment. The Qualified Medical Physicist must also be familiar with relevant clinical procedures.

IV. NUCLEAR MEDICINE REFERENCE LEVELS FOR IMAGING WITH IONIZING RADIATION

The concept of the RL can be a practical tool in nuclear medicine. Achieving acceptable diagnostic information, consistent with the medical imaging task, is the overriding clinical objective. The quantity that is recommended for RLs and AAAs is the administered activity or dosage. Administered activity RLs (in MBq or MBq/kg of body weight) are then used to help manage the radiation dose to patients so that the organ doses are appropriate for the clinical purpose.

The physician listed on the regulatory license or certificate (often called the authorized user) is ultimately responsible for the supervision and appropriate utilization of all radiopharmaceuticals received, prepared, or administered under his or her direction.

It is strongly recommended that each administered dosage be assayed onsite at the medical facility prior to administration to verify the prescribed activity[1].

Determining RLs for nuclear medicine procedures is difficult due to the limited available survey data, number of radiopharmaceuticals used, and variability in procedures. Due to the limited availability of survey data, local assessment may be necessary. For pediatric procedures, the standard is based on recommended activity per unit body mass. For adults, manufacturers recommend a standard administered activity based on a standard 70 kg person in their package insert as required by the US Food and Drug Administration. Guidelines for minimum and

maximum administered activities for adults and children are available from various publications [1-13,17]. This is the initial practice parameter on nuclear medicine RLs. Although the recommendations are based on limited survey data, they are the best available data we have for the modality.

Reference levels and AAAs are part of the optimization process. It is essential to assure that image quality appropriate for the diagnostic purpose is maintained when modifying administered activity. Optimization must balance image quality and patient absorbed dose, ie, image quality must be maintained at an appropriate level as administered activity is decreased. If diagnostic quality images are not achievable using the RLs or AAAs presented in Tables 1 and 2 due to requirements of particular imaging devices or patient weight, the recommended RLs may need to be exceeded.

Table 1 summarizes the RLs and AAAs for common radiopharmaceuticals administered to adults. It uses data obtained from NCRP 172 and Collaborative Practice Parameters and Procedural Guidelines from the ACR, Society of Nuclear Medicine and Molecular Imaging, and American Society of Nuclear Cardiology [1-11,17]. It is important to note that the NCRP 172 data tables are the results of multiple surveys of clinical facilities and the Collaborative Practice Parameters and Procedural Guidelines are recommended administered activity ranges. The RLs and AAAs in Table 1 were determined using the 75th percentile and 50th percentile of the NCRP data, respectively, and 75% and 50% of the range of recommended administered activities for the Collaborative Practice Parameters and Procedural Guidelines, respectively.

TABLE 1
Radiopharmaceutical Administered Activity in Adults

Radiopharmaceutical	Minimum Administered Activity	Achievable Administered Activity¹	Reference Level Administered Activity²
¹⁸ F-Fluorodeoxyglucose (FDG)	370 MBq (8.0 mCi)	555 MBq (15 mCi)	650 MBq (18.5 mCi)
⁶⁷ Ga-Citrate	185 MBq (5.0 mCi)	280 MBq (7.5 mCi)	325 MBq (8.8 mCi)
¹²³ I-Metaiodobenzylguanidine (MIBG) (1)	185 MBq (5.0 mCi)	280 MBq (7.5 mCi)	325 MBq (8.8 mCi)
¹²³ I-Sodium Iodide (Nal)	7.4 MBq (0.2 mCi)	11 MBq (0.3 mCi)	13.0 MBq (0.35 mCi)
¹¹¹ In-Oxine Leukocytes	11 MBq (0.3 mCi)	24 MBq (0.7 mCi)	30 MBq (0.8 mCi)
^{99m} Tc-Dimercaptosuccinic Acid (DMSA) (1)	130 MBq (3.5 mCi)	160 MBq (4.25 mCi)	170 MBq (4.6 mCi)
^{99m} Tc-Disofenin or Mebrofenin (hepatobiliary) (1)	111 MBq (3.0 mCi)	150 MBq (4.0 mCi)	167 MBq (4.5 mCi)
^{99m} Tc-Exametazime (HMPAO) Leukocytes	185 MBq (5.0 mCi)	460 MBq (12.5 mCi)	600 MBq (16.2 mCi)
^{99m} Tc-Labeled Solids (GI emptying)	3.7 MBq (0.1 mCi)	41 MBq (1.1 mCi)	50 MBq (1.3 mCi)
^{99m} Tc-Macroaggregated Albumin	111 MBq (3.0 mCi)	150 MBq (4.0 mCi)	167 MBq (4.5 mCi)
^{99m} Tc-Mertiatide (MAG3)	130 MBq (3.5 mCi)	250 MBq (6.8 mCi)	310 MBq (8.4 mCi)
^{99m} Tc-Medronate (MDP)	555 MBq (15 mCi)	835 MBq (23 mCi)	970 MBq (26 mCi)
^{99m} Tc-Sestamibi or Tetrofosmin One-day Protocol (cardiac rest/stress)	296/888 MBq (8/24 mCi)	370/1110 MBq (10/30 mCi)	407/1221 MBq (11/33 mCi)
^{99m} Tc-Sestamibi or Tetrofosmin Two-day Protocol (cardiac rest/stress)	925 MBq per day (25 mCi per day)	1018 MBq per day (27.5 mCi per day)	1073 MBq per day (29 mCi per day)
^{99m} Tc-Sestamibi or Tetrofosmin, (cardiac stress-only protocol)	518 MBq (14 mCi)	888 MBq (24 mCi)	1073 MBq (29 mCi)
²⁰¹ Tl-Chloride (cardiac rest/stress)	37 MBq (1.0 mCi)	165 MBq (4.4 mCi)	172 MBq (4.6 mCi)

¹ 50% of range recommended

² 75% of range recommended

Table 2 summarizes the RLs and AAAs for radiopharmaceuticals commonly used for pediatric procedures. It uses data obtained from NCRP 172 and North American Consensus guidelines [12,13,17]. It is important to note that the NCRP 172 data tables are based on multiple surveys of clinical facilities, and the North American Consensus Guidelines are recommended administered activity ranges. The RLs and AAAs for Table 2 were determined using the 75th percentile and 50th percentile of the NCRP data, respectively, and 75% and 50% of the range of recommended administered activities for the North American Consensus guidelines, respectively. Table 2 data are primarily taken from the North American Consensus Guidelines. The NCRP 172 survey data were used for those procedures that were not included in the North American Consensus Guidelines. Where no maximum administered activity was provided, the maximum administered activity was determined using the higher end of the range for the recommended administered activity per kg, multiplied by the weight for a 70 kg patient. Thus, if the child's weight exceeds 70 kg, the maximum should not be that for a standard adult. If diagnostic quality images are not achievable for the RLs and AAAs presented in Table 2, then the recommended RLs may need to be exceeded.

TABLE 2
Radiopharmaceutical Administered Activity for Children

Radiopharmaceutical	Recommended Administered Activity Range/kg (based on weight only)	Minimum Administered Activity	Achievable Administered Activity¹	Reference Level Administered Activity²
¹⁸ F-Fluorodeoxyglucose (FDG) - Body	3.7 – 5.2 MBq/kg (0.10 – 0.14 mCi/kg)	26 MBq (0.7 mCi)	195 MBq (5.3 mCi)	280 MBq (7.5 mCi)
¹⁸ F-Fluorodeoxyglucose (FDG) - Brain	3.7 MBq/kg (0.10 mCi/kg)	14 MBq (0.4 mCi)	137 MBq (3.7 mCi)	198 MBq (5.4 mCi)
¹⁸ F-Sodium Fluoride	2.22 MBq/kg (0.06 mCi/kg)	14 MBq (0.4 mCi)	85 MBq (2.3 mCi)	120 MBq (3.3 mCi)
⁶⁷ Ga (for inflammatory disease)	1.48 – 2.59 MBq/kg (0.04 – 0.07 mCi/kg)	9.25 MBq (0.25 mCi)	167 MBq (4.5 mCi)	167 MBq (4.5 mCi)
⁶⁷ Ga (for tumor imaging)	2.96 – 5.25 MBq/kg (0.08 – 0.14 mCi/kg)	9.25 MBq (0.25 mCi)	333 MBq (9.0 mCi)	333 MBq (9.0 mCi)
¹²³ I-Metaiodobenzylguanidine (MIBG)	5.2 MBq/kg (0.14 mCi/kg)	37 MBq (1.0 mCi)	204 MBq (5.5 mCi)	287 MBq (7.8 mCi)
¹²³ I-Sodium Iodide (Ial) for Thyroid	0.06 – 0.22 MBq/kg (0.002 – 0.006 mCi/kg)	0.56 MBq (0.015 mCi)	8.14 MBq (0.2 mCi)	9.45 MBq (0.3 mCi)
^{99m} Tc-Dimercaptosuccinic Acid (DMSA)	1.85 MBq/kg (0.05 mCi/kg)	18.5 MBq (0.5 mCi)	59.3 MBq (1.6 mCi)	80 MBq (1.9 mCi)
^{99m} Tc-Disofenin (IDA) (hepatobiliary)	1.85 MBq/kg (0.05 mCi/kg)	18.5 MBq (0.5 mCi)	74.3 MBq (2.0 mCi)	102 MBq (2.8 mCi)
^{99m} Tc-Macroaggregated Albumin – if ^{99m} Tc used for Ventilation	2.59 – 4.88 MBq/kg (0.07 – 0.13 mCi/kg)	34.5 MBq (0.9 mCi)	188 MBq (5.0 mCi)	265 MBq (7.0 mCi)
^{99m} Tc-Macroaggregated Albumin – No ^{99m} Tc Ventilation	1.11 MBq/kg (0.03 mCi/kg)	14.8 MBq (0.4 mCi)	46.3 MBq (1.3 mCi)	62 MBq (1.7 mCi)
^{99m} Tc-Mertiatide (MAG3) without Flow Study	3.7 MBq/kg (0.10 mCi/kg)	37 MBq (1.0 mCi)	92.5 MBq (2.5 mCi)	120 MBq (3.3 mCi)
^{99m} Tc-Mertiatide (MAG3) with Flow Study	5.55 MBq/kg (0.15 mCi/kg)	37 MBq (1.0 mCi)	213 MBq (5.8 mCi)	301 MBq (8.1 mCi)
^{99m} Tc-Medronate (MDP)	9.3 MBq/kg (0.25 mCi/kg)	37 MBq (1.0 mCi)	740 MBq (9.25 mCi)	820 MBq (13.375 mCi)
^{99m} Tc-Pertechnetate (meckel diverticulum imaging)	1.85 MBq/kg (0.05 mCi/kg)	9.25 MBq (0.25 mCi)	70 MBq (1.9 mCi)	100 MBq (2.7 mCi)
^{99m} Tc-Sulfur Colloid (for oral liquid gastric emptying)	Not weight based	9.25 MBq (0.25 mCi)	23.1 MBq (0.6 mCi)	30 MBq (0.8 mCi)
^{99m} Tc-Sulfur Colloid (for solid gastric emptying)	Not weight based	9.25 MBq (0.25 mCi)	13.9 MBq (0.4 mCi)	16.2 MBq (0.4 mCi)
^{99m} Tc-Ulratage (for GI bleeding)	3.7 – 11.0 MBq/kg (0.10 – 0.30 mCi/kg)	37 MBq (1.0 mCi)	740 MBq (20.0 mCi)	740 MBq (20.0 mCi)
^{99m} Tc-Sestamibi	5.7 – 19.0 MBq/kg (0.154 – 0.50 mCi/kg)	37 MBq (1.0 mCi)	777 MBq (21.0 mCi)	792 MBq (21.0 mCi)
^{99m} Tc (different forms) for Cystography	Not weight based		18.5 MBq (0.5 mCi)	28 MBq (0.75 mCi)

¹ 50% of range recommended

² 75% of range recommended

V. PATIENT SPECIFIC DOSIMETRY

Internal absorbed dose can be estimated from anthropomorphic computer models and used for comparison of radiation dose among procedures. Although dose estimates are available for children of various ages, adult males and females as well as for pregnant females at different gestational stages, they are based on specific body-size estimates and tracer kinetics, which may be very different for any individual patient [19-22].

On occasion the need may arise to estimate the dose delivered to an individual patient because of a specific situation (eg, pregnancy or referring physician request). In these situations it is recommended that the physician consider executing a formal written medical physics consultation with the Qualified Medical Physicist. Using the information about the patient's weight, administered activity, and the radiopharmaceutical, the Qualified Medical Physicist can render an estimate of the specific dose to tissue and organs in the patient. The consultation request and the Qualified Medical Physicist's report should be duly signed by the requesting physician and the Qualified Medical Physicist and should be incorporated into the patient's medical record.

VI. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels) http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf.

Facilities and their responsible staff should consult with the radiation safety officer to ensure that there are policies and procedures for the safe handling and administration of radiopharmaceuticals and that they are adhered to in accordance with ALARA. These policies and procedures must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) and by state and/or other regulatory agencies. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol.

Nationally developed guidelines, such as the [ACR's Appropriateness Criteria®](#), should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

For the purpose of this practice parameter the radiation dose index used is administered activity of the radiopharmaceutical.

VII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

Performance evaluation, quality control, acceptance testing, written survey reports, and follow-up procedures of all nuclear medicine and PET imaging systems and support equipment should be in accordance with the appropriate ACR Medical Physics Technical Standards (<http://www.acr.org/Quality-Safety/Standards-Guidelines/Technical-Standards-by-Modality/Medical-Physics>).

The Qualified Medical Physicist should report on an annual basis a review of the most common nuclear medicine and PET protocols for adults and pediatric patients performed at the facility. The report should include estimates of radiation dose based on administered activity and a comparison of these estimates with current RLs and should provide recommendations for improvement if the dose estimates or administered activity exceed the RLs.

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (<http://www.acr.org/guidelines>) by the Committee on Practice Parameters and Technical Standards – Medical Physics of the ACR Commission on Medical Physics and the Committee on Practice Parameters and Technical Standards – Nuclear Medicine and Molecular Imaging of the ACR Commission on Nuclear Medicine and Molecular Imaging in collaboration with the AAPM.

Collaborative Committee

Members represent their societies in the initial and final revision of this practice parameter.

ACR

Thomas G. Ruckdeschel, MS, Chair
Maxwell R. Amurao, PhD, MBA
Murray D. Becker, MD, PhD
Bennett S. Greenspan, MD, MS, FACR
Ralph P. Lieto, MS, FACR, FAAPM
Osama Mawlawi, PhD
Susan Passalacqua, MD

AAPM

Jerry D. Allison, PhD, FACR, FAAPM
Beth A. Harkness, MS, FACR
Mark T. Madsen, PhD, FACR, FAAPM

Committee on Practice Parameters and Technical Standards – Medical Physics

(ACR Committee responsible for sponsoring the draft through the process)

Tariq A. Mian, PhD, FACR, FAAPM, Chair
Charles M. Able, MS
Maxwell R. Amurao, PhD, MBA
Ishtiaq H. Bercha, MSc
Caridad Borrás, DSc, FACR, FAAPM
Chee-Wai Cheng, PhD, FAAPM
Ralph P. Lieto, MS, FACR, FAAPM
Matthew A. Pacella, MS

William Pavlicek, PhD
Douglas E. Pfeiffer, MS, FACR, FAAPM
Thomas G. Ruckdeschel, MS
Christopher J. Watchman, PhD
John W. Winston, Jr., MS

Committee on Practice Parameters and Technical Standard – Nuclear Medicine and Molecular Imaging
(ACR Committee responsible for sponsoring the draft through the process)

Bennett S. Greenspan, MD, MS, FACR, Co-Chair
Christopher J. Palestro, MD, Co-Chair
Thomas W. Allen, MD
Kevin P. Banks, MD
Murray D. Becker, MD, PhD
Richard K.J. Brown, MD, FACR
Shana Elman, MD
Perry S. Gerard, MD, FACR
Warren R. Janowitz, MD, JD, FACR
Chun K. Kim, MD
Charito Love, MD
Joseph R. Osborne, MD, PhD
Darko Pucar, MD, PhD
Rathan M. Subramaniam, MD, PhD, MPH
Scott C. Williams, MD

Richard A. Geise, PhD, FACR, FAAPM, Chair, Commission on Medical Physics
M. Elizabeth Oates, MD, Chair, Commission on Nuclear Medicine and Molecular Imaging
Debra L. Monticciolo, MD, FACR, Chair, Commission on Quality and Safety
Jacqueline A. Bello, MD, FACR, Vice Chair, Commission on Quality and Safety
Julie K. Timins, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards
Matthew S. Pollack, MD, FACR, Vice Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee

Darlene F. Metter, MD, FACR, Chair
Paul Nagy, PhD, Co-Chair
Adam M. Alessio, PhD
Jerry D. Allison, PhD, FACR, FAAPM
Maxwell R. Amurao, PhD, MBA
Kimberly E. Applegate, MD, MS, FACR
Murray D. Becker, MD, PhD
Ishtiaq H. Bercha, MSc
Richard A. Geise, PhD, FACR, FAAPM
Bennett S. Greenspan, MD, MS, FACR
Beth A. Harkness, MS, FACR
William T. Herrington, MD, FACR
Edwin M. Leidholdt Jr., PhD
Ralph P. Lieto, MS, FACR, FAAPM
Mark T. Madsen, PhD, FACR, FAAPM
Osama Mawlawi, PhD
Tariq A. Mian, PhD, FACR, FAAPM
Debra L. Monticciolo, MD, FACR
Jonathon A. Nye, PhD

M. Elizabeth Oates, MD
Christopher J. Palestro, MD
Susan Passalacqua, MD
William Pavlicek, PhD
Thomas G. Ruckdeschel, MS
Julie K. Timins, MD, FACR
William G. West, PhD

REFERENCES

1. American College of Radiology. ACR-SNM technical standard for diagnostic procedures using radiopharmaceuticals. 2011; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/RadioPharm.pdf>. Accessed August 6, 2014.
2. American College of Radiology. ACR-SPR practice parameter for performing FDG-PET/CT in oncology. 2012; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/FDG-PET-CT.pdf>. Accessed August 6, 2014.
3. American College of Radiology. ACR-SPR practice parameter for the performance of hepatobiliary scintigraphy. 2013; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Hepato-Scint.pdf>. Accessed August 6, 2014.
4. American College of Radiology. ACR-SPR practice parameter for the performance of renal scintigraphy. 2013; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/RenalScint.pdf>. Accessed August 6, 2014.
5. American College of Radiology. ACR-SPR practice parameter for the performance of skeletal scintigraphy (bone scan). 2013; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Skeletal-Scint.pdf>. Accessed August 6, 2014.
6. American College of Radiology. ACR-SPR-STR practice parameter for the performance of pulmonary scintigraphy. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/PulmonayScint.pdf>. Accessed August 6, 2014.
7. American College of Radiology. ACR-SPR practice parameter for the performance of scintigraphy and uptake measurements for benign and malignant thyroid disease. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Thy-Scint.pdf>. Accessed August 6, 2014.
8. American College of Radiology. ACR-SPR practice parameter for the performance of scintigraphy for inflammation and infection. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/InflamInfScint.pdf>. Accessed August 7, 2014.
9. Chang SM, Nabi F, Xu J, Raza U, Mahmariam JJ. Normal stress-only versus standard stress/rest myocardial perfusion imaging: similar patient mortality with reduced radiation exposure. *J Am Coll Cardiol*. 2010;55(3):221-230.
10. Depuey EG, Mahmariam JJ, Miller TD, et al. Patient-centered imaging. *J Nucl Cardiol*. 2012;19(2):185-215.
11. Dorbala S, Di Carli MF, Delbeke D, et al. SNMMI/ASNC/SCCT guideline for cardiac SPECT/CT and PET/CT 1.0. *J Nucl Med*. 2013;54(8):1485-1507.
12. Gelfand MJ, Parisi MT, Treves ST. Pediatric radiopharmaceutical administered doses: 2010 North American consensus guidelines. *J Nucl Med*. 2011;52(2):318-322.
13. Lassmann M, Treves ST. Paediatric radiopharmaceutical administration: harmonization of the 2007 EANM paediatric dosage card (version 1.5.2008) and the 2010 North American consensus guidelines. *Eur J Nucl Med Mol Imaging*. 2014;41(5):1036-1041.
14. Diagnostic reference levels in medical imaging: review and additional advice. *Ann ICRP*. 2001;31(4):33-52.
15. International Commission on Radiological Protection. *Against ionizing radiation from external sources*. Bethesda, MD: ICRP Report 21: Publication 60; 1990.
16. International Commission on Radiological Protection. *Radiological protection and safety in medicine*. Bethesda, Md: ICRP Report: Publication 73; 1996.

17. National Council on Radiation Protection and Measurements. NCRP Report No. 172. *Reference levels and achievable doses in medical and dental imaging: recommendations for the United States*. Bethesda, MD;2012.
18. American College of Radiology. ACR practice parameter for continuing medical education (CME). 2011; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CME.pdf>. Accessed August 20, 2014.
19. Stabin MG, Xu XG, Emmons MA, Segars WP, Shi C, Fernald MJ. RADAR reference adult, pediatric, and pregnant female phantom series for internal and external dosimetry. *J Nucl Med*. 2012;53(11):1807-1813.
20. International Commission on Radiological Protection. Radiation dose to patients from radiopharmaceuticals. 1988; Available at: <http://www.icrp.org/publication.asp?id=ICRP%20Publication%2053>. Accessed November 18, 2014.
21. International Commission on Radiological Protection. Radiation dose to patients from radiopharmaceuticals (addendum to ICRP publication 53). 1998; Available at: <http://www.icrp.org/publication.asp?id=ICRP%20Publication%2080>. Accessed November 18, 2014.
22. International Commission on Radiological Protection. Radiation dose to patients from radiopharmaceuticals (addendum 3 to ICRP publication 53). 2008; Available at: <http://www.icrp.org/publication.asp?id=ICRP%20Publication%20106>. Accessed November 18, 2014.

APPENDIX A

This addendum table is taken from the NCRP Report 172 to illustrate survey results for adult administered activities. The survey data was reflective of the responses from “selected nuclear medicine departments at academic centers.” The minimum and maximum values are reflective of the practice of nuclear medicine in 2010 without necessarily assessing if the administered activity was optimized by the respective facility or recommended from another source. Accordingly, the range from the survey is wide for some radiopharmaceutical studies.

**Recommended Radiopharmaceutical Administered Activity for Adults
From NCRP Report 172, Table 6.16**

Radiopharmaceutical	Minimum Administered Activity	Maximum Administered Activity	Recommended Achievable Administered Activity¹	Recommended Reference Levels²
¹⁸ F-Fluorodeoxyglucose (FDG)	269 MBq (8.0 mCi)	814 MBq (22.0 mCi)	666 MBq (18.0 mCi)	710 MBq (19.0 mCi)
¹²³ I-Metaiodobenzylguanidine (MIBG)	19.0 MBq (0.5 mCi)	407 MBq (11.0 mCi)	370 MBq (10.0 mCi)	391 MBq (11.0 mCi)
¹²³ I-Sodium Iodide (I ¹²³ I)	3.7 MBq (0.1 mCi)	22 MBq (0.6 mCi)	12 MBq (0.3 mCi)	26 MBq (0.7 mCi)
^{99m} Tc-Dimercaptosuccinic Acid (DMSA)	3.7 MBq (0.1 mCi)	407 MBq (11.0 mCi)	185 MBq (5.0 mCi)	289 MBq (7.8 mCi)
^{99m} Tc-Disofenin or Mebrofenin (hepatobiliary)	19.0 MBq (0.5 mCi)	370 MBq (10.0 mCi)	222 MBq (6.0 mCi)	282 MBq (7.6 mCi)
^{99m} Tc-Labeled Solids (GI emptying)	3.7 MBq (0.1 mCi)	74 MBq (2.0 mCi)	41 MBq (1.1 mCi)	50 MBq (1.3 mCi)
^{99m} Tc-Macroaggregated Albumin	19.0 MBq (0.5 mCi)	244 MBq (6.6 mCi)	222 MBq (6.0 mCi)	226 MBq (6.1 mCi)
^{99m} Tc-Mertiatide (MAG3)	11.1 MBq (0.3 mCi)	407 MBq (11.0 mCi)	370 MBq (10.0 mCi)	379 MBq (10.0 mCi)
^{99m} Tc-Medronate (MDP)	370 MBq (10.0 mCi)	1480 MBq (40 mCi)	1064 MBq (29.0 mCi)	1185 MBq (32.0 mCi)
^{99m} Tc-Sestamibi (cardiac rest)	148 MBq (4.0 mCi)	1665 MBq (45.0 mCi)	907 MBq (25.0 mCi)	1153 MBq (31.0 mCi)
^{99m} Tc-Sestamibi (cardiac stress)	148 MBq (4.0 mCi)	1665 MBq (45.0 mCi)	1277 MBq (35.0 mCi)	1452 MBq (39.0 mCi)
^{99m} Tc-Tetrofosmin (cardiac rest)	148 MBq (4.0 mCi)	1665 MBq (45.0 mCi)	907 MBq (25.0 mCi)	1089 MBq (29.0 mCi)
^{99m} Tc-Tetrofosmin (cardiac stress)	148 MBq (4.0 mCi)	1776 MBq (48.0 mCi)	1295 MBq (35.0 mCi)	1459 MBq (39.0 mCi)
²⁰¹ Tl-Chloride (cardiac rest/stress)	37 MBq (2.0 mCi)	185 MBq (5.0 mCi)	165 MBq (4.4 mCi)	172 MBq (4.6 mCi)

¹ Median maximum value used

² 75th percentile maximum value used

*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised, or approved by the ACR Council. For practice parameters and technical

standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

Development Chronology for this Practice Parameter
2015 (Resolution 53)