The Society of Nuclear Medicine and Molecular Imaging (SNMMI) is an international scientific and professional organization founded in 1954 to promote the science, technology, and practical application of nuclear medicine. The European Association of Nuclear Medicine (EANM) is a professional nonprofit medical association that facilitates communication worldwide between individuals pursuing clinical and research excellence in nuclear medicine. The EANM was founded in 1985. SNMMI and EANM members are physicians, technologists, and scientists specializing in the research and practice of nuclear medicine.

The SNMMI and EANM will periodically define new guidelines for nuclear medicine practice to help advance the science of nuclear medicine and to improve the quality of service to patients throughout the world. Existing practice guidelines will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline, representing a policy statement by the SNMMI/EANM, has undergone a thorough consensus process in which it has been subjected to extensive review. The SNMMI and EANM recognize that the safe and effective use of diagnostic nuclear medicine imaging requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline by those entities not providing these services is not authorized.

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THE SNMMI and EANM PRACTICE GUIDELINE FOR TELENUCLEAR MEDICINE DRAFT V2.0

J. Anthony Parker, Bernhard Sattler, Paul E. Christian, Hossein Jadvar, and Jerold Wallis

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, both the SNMMI and the EANM caution against the use of these guidelines 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 physician or medical physicist in light of all the circumstances presented. Thus, there is no implication that an approach differing from the guidelines, standing alone, is below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines 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 the guidelines.

The practice of medicine includes both the art and the science of 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 these guidelines will not ensure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable 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 these guidelines is to assist practitioners in achieving this objective.
I. INTRODUCTION

Tele-nuclear medicine may improve health care by allowing more timely interpretation and facilitating consultation. For example, it may enable increased availability of nuclear medicine in under-served areas. Picture Archiving and Communication Systems (PACS)\(^1\) are increasingly able to provide a remote workstation environment similar to the on-site environment (client-server concept). This guideline focuses on tele-nuclear medicine separate from the main PACS capabilities i.e. on the remote clients of the PACS.

II. GOALS

The goal of this guideline is to assist nuclear medicine practitioners in using tele-nuclear medicine for interpretation and consultation of nuclear medicine studies.

III. DEFINITIONS

See also the SNM Guideline for General Imaging.

Tele-nuclear medicine refers to nuclear medicine interpretation or consultation at a location distant from the location the data are acquired. There is a continuum of separation between the physical location of the acquisition and interpretation, but tele-nuclear medicine is meant to imply that the interpretation is relatively remote as compared with the typical interpretation.

Tele-nuclear medicine equipment is used to implement tele-nuclear medicine. The same equipment may be used for both on-site and tele-nuclear medicine\(^2,3\). This guideline will focus on the special considerations required when nuclear medicine equipment is used at remote locations. Distribution of images in a single imaging center falls into the realm of PACS (Picture Archiving and Communications Systems), and is not the major focus of this document.

IV. COMMON CLINICAL INDICATIONS

Common indications for Tele-Nuclear Medicine include, but are not limited to the following:

A. To interpret routine studies at a remote location.

B. To interpret emergency studies in an on-call setting.

C. To provide consultation.

V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL (in the United States)

See SNM Guideline for General Imaging.

VI. PROCEDURE/SPECIFICATIONS OF THE EXAMINATION
See also the SNM Guideline for General Imaging.

A. Types of tele-nuclear medicine systems

1. Tele-nuclear medicine can be implemented a) using a nuclear medicine only system, b) as a part of a tele-radiology system, or c) as part of another tele-imaging system. In the latter two cases, an effort should be made to include nuclear medicine specific capabilities required for the type of study being viewed.

2. A remote station can be implemented

   a. Using a standard nuclear medicine physician workstation.
   b. Using a remote display of a nuclear medicine physician workstation.
   c. Using a remote viewing station (e.g. using a browser or with installation of remote viewing software).

B. Data Completeness

1. All of the information needed for interpretation or consultation should be available to the physician at the remote location. This information includes demographic data, history, results of other relevant tests, procedure details, scintigraphic data, and relevant correlative and structural imaging as for instance CT and MRI data.

2. All image data must be explicitly associated with patient identifier and appropriate label information.

C. Data Visualization

1. The remote station should allow the same or equivalent display and processing functions as those used for interpretation or consultation at an on-site physician workstation. If the tele-nuclear medicine application involves a limited range of procedures, then all of the functions needed to interpret or consult on these procedures should be provided.

2. Small displays (smart phones or tablets) may facilitate consultation with colleagues, but they will have limited utility for interpretation or reporting.

3. The following general abilities facilitate remote viewing:

   a. Ability to simultaneously display comparison studies with current and comparison data.
   b. Ability to adjust the size of the display viewport.
   c. Ability to pan and zoom.
d. Ability to simultaneously show images of different sizes.

e. Ability to display image sequences in cine or montage format.

4. The following abilities provide control of the display intensity:

a. Ability to display image data in gray scale or color and scale the intensity to fewer levels (e.g. 256 levels) for on-screen display.

b. Ability to adjust upper and lower levels interactively for each dataset.

c. Ability to determine the upper and lower pixel values used for scaling the display. This will help avoid scaling artifacts due to too few gray levels when data with a large dynamic range is reduced to fewer levels for display.

d. Ability to choose from a set of color tables.

e. Ability to apply lookup tables to adjust contrast, or otherwise adjust contrast.

f. Ability to add additional lookup tables.

5. The following abilities facilitate planar image display:

a. Ability to display complete images ranging in size from 64x64 to 1024x1024, including images that are not square and not powers of two.

b. Ability to display a 1024x1024 or 512x1024 whole-body image centered within a smaller width frame (e.g. 256 pixels wide), intelligently trimming zero or near-zero count regions from the periphery of the image to make better use of screen area.

c. Ability to simultaneously display whole-body images (e.g. 1024x256) and spot images (e.g. 256x256).

d. Ability to display a sequence of images scaled to a common maximum pixel value, or individually scaled based on the maximum pixel value in each image.

6. The following abilities facilitate dynamic image display:

a. Ability to cine a dynamic sequence, up to 256x256 matrix size, 256 frames, scaled to a common maximum pixel value, or individually scaled based on the maximum pixel value in each image.

b. Ability to reframe data (by combining images into a fewer number of frames) at time of display.

c. Ability to interactively change display thresholds and speed on each cine.
7. The following abilities facilitate gated planar image display:

   a. Ability to cine at least 3 views (8-32 frames, 64x64 -128x128 matrix size), at up to one full cardiac cycle per second.

   b. Ability to display views simultaneously and synchronously, preferably including the option for simple filtering (e.g. 9-point smooth).

   c. Ability to display simultaneously at least two studies each with at least 3 views.

8. The following abilities will facilitate tomographic image display (PET, SPECT, PET/CT, PET/MRI and SPECT/CT):

   a. Ability to fuse separate anatomic and molecular imaging data.

   b. Ability to generate coronal, sagittal, or oblique images for display from a transaxial dataset.

   c. Ability to display multiple frames from a single axis, frames from three orthogonal axes, or an interactive multi-axis display.

   d. Ability on the multi-axis display to display at least 1-3 transaxial slices, 1-3 coronal slices, 1-3 sagittal slices, and 1 cine, simultaneously.

   e. Ability of the user to navigate the multi-axis display, including the ability to click on any plane with automatic adjustment of the other two planes to that position.

   f. Ability to toggle on and off cursors on the multi-axis display showing the other image planes.

   g. Ability to adjust slice thickness at time of display.

9. Display functions provided by myocardial analysis software packages enjoy considerable popularity. A remote station may provide this display functionality by:

   a. Running one of these packages.

   b. Displaying the processed screens (including designated cine screens) from these packages. Such display should include the abilities to adjust upper and lower levels, and apply color lookup tables to the processed screens, as described above for other nuclear medicine images.

10. Intra- and inter- modality registration may enable enhanced interpretation or consultation.

D. Processing
1. Minimal processing abilities should include:
   
a. Ability to measure the value of a pixel or the average value from a region-of-interest.
   
b. Ability to show the same quantitative data available on-site, e.g. $SUV_{\text{max}}$ and $SUV_{\text{mean}}$ normalizing for body weight or body surface area from a 2- or 3-dimensional region-of-interest.
   
c. Ability to smooth images (e.g. by a simple 9-point smooth) [recommended but not required].
   
2. Other processing may be included as necessary for a particular remote application, e.g. display an activity profile, perform renal analysis, calculate gallbladder emptying, or calculate gastric emptying.

E. Communications

1. The communications protocol should allow for confirmation of reliable transmission.
2. Encrypted transmission of data will improve the security of transmission over public channels.
3. Many current communication technologies provide adequate speed for most tele-nuclear medicine applications. In the on-call setting, correlative imaging requirements will generally dominate selection of a communication speed.

F. Compression

1. Data compression can be used to improve the speed of data transmission, although speed of transmission may not be an issue for nuclear medicine data alone. If structural data are included, speed is an issue.
2. Compression can be either lossless, where the uncompressed data are identical to the original, or lossy, where the uncompressed data are altered when compared to the original. If lossy compression is used, the remote data should be diagnostically comparable to the original.

G. Monitor Quality Control\textsuperscript{6,7}

1. Considerations
   
a. The remote location may present special consideration for the quality control of the monitor used for display of nuclear medicine information.
   
b. The remote monitor should have the same quality control as on-site monitors (see SNM Guideline for General Imaging VI.D.5.iv).
c. Remote monitors, particularly for the on-call application, may have multiple uses, and
the monitor set up may be altered by non-nuclear medicine applications. Alterations
to the color depth of the display (e.g. 256 colors versus millions of colors) may
significantly affect image interpretation, yet not be immediately apparent on casual
inspection of image data.

2. Test Patterns

a. A test pattern such as the Society of Motion Picture and Television Engineers
(SMPTE) Medical Diagnostic Imaging Test Pattern may be used to check monitor
spatial resolution and linearity. For the SMPTE pattern, the lines should appear
linear, and line pairs of different widths should all be visible and have the same
contrast.

b. A test pattern such as the SMPTE may be used to check gray scale linearity. For the
SMPTE, the 5% and 95% boxes should be visible, and the change between intensity
levels should appear linear.

c. A test pattern such as the Brigham and Women’s Hospital test pattern can be used to
check for discontinuities in the gray scale, which can produce artificial edges in image
data. For the Brigham and Women’s Hospital test pattern, the change in intensity
should be continuous without any visible rings. (see
http://parker.bidmc.harvard.edu/TestPatterns.html)

d. The remote monitor should be checked visually for any gross color dysfunction (e.g.
missing of one of the R G B signals). If a locally installed color scale is used for
remote viewing, it should be verified that it is visually similar to that installed at the
primary site, with color transitions at the same locations.

3. Quality Control Procedures

a. Full monitor quality control (AAPM TG18 Report) is not practical for remote sites;
however, relatively simple test patterns should be readily displayable.

b. There should be a regular protocol and schedule of quality control testing.

c. In some multiuse settings, quality control may need to be tested for each tele-nuclear
medicine session.

d. Tele-nuclear medicine systems that show test pattern(s) at the time of login facilitate
regular quality control.

H. Security

1. Nuclear medicine data, including the fact that a procedure was performed, are
confidential medical information.
2. The goal of security is to decrease the probability of unauthorized access while impeding authorized access as little as possible.

3. The benefit from increased security should be balanced against costs, including the cost of decreased availability of information for authorized users.

4. Electronic transmission of nuclear medicine data should be made more secure than traditional non-digital hospital practices.

5. An effort should be made to limit access only to authorized individuals both in transit and at the tele-nuclear medicine site. Security includes login, communications, and access to data stored on the remote system.

6. A time-out period that is appropriate for the environment in which the remote workstation is being used may be implemented.

7. It is anticipated that nuclear medicine is a low priority target, and the image portion of the data is meaningful to a limited audience. Thus, it may be appropriate to place greater security emphasis on securing system login procedures and access to medical databases containing patient information, rather than encryption of pure image data.

8. There should be a disaster recovery plan dealing with breach of system security or loss of source data due to malfunction of the equipment.

J. Issues Requiring Further Clarification

1. The extent to which lossy compression provides diagnostically equivalent information when used for either primary interpretation or for correlative images needs further clarification.

2. Remote interpretation legal issues are still in evolution.

VI. DOCUMENTATION/REPORTING

See SNM Guideline for General Imaging

VIII. EQUIPMENT SPECIFICATION

Equipment specification for each procedure is given in the respective procedure guidelines.

IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

See also the SNM Guideline for General Imaging.
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 Patient Education Concerns appearing elsewhere in the ACR Practice Guidelines and Technical Standards book.

Physician quality control should also be done regularly to assure consistent, accurate physician interpretation of results. The ACR RadPeer system offers one method of achieving this goal; however, RadPeer is not mandatory and equivalent systems may be used.

Equipment performance monitoring should be in accordance with ACR Technical Standards for Medical Nuclear Physics Performance Monitoring of Computed Tomography (CT) and Nuclear Medicine Equipment.

Information specific to the procedure should also be included in each guideline.

X. RADIATION SAFETY IN IMAGING

See appropriate study guideline.

XI. ACKNOWLEDGEMENTS

Task Force Members (V2.0): NEEDS UPDATING—Listing is from V1.0

J. Anthony Parker, MD, PhD (Beth Israel Deaconess Medical Center, Boston, MA); Jerold W. Wallis, MD (Mallinckrodt Institute of Radiology, St. Louis, MO); Hossein Jadvar, MD, PhD (University of Southern California Keck School of Medicine, Los Angeles, CA); Paul Christian, CNMT (Huntsman Cancer Institute, University of Utah, Salt Lake City, UT); and Bernhard Sattler, PhD, MPE (EANM Physics Committee, Vienna, Austria; University Hospital Leipzig, Leipzig, Germany).

Committee on Guidelines:

Kevin J. Donohoe, MD (Chair) (Beth Israel Deaconess Medical Center, Boston, MA); Sue Abreu, MD (Sue Abreu Consulting, Nichols Hills, OK); Helena Balon, MD (Beaumont Health System, Royal Oak, MI); Twyla Bartel, DO (UAMS, Little Rock, AR); Paul E. Christian, CNMT, BS, PET (Huntsman Cancer Institute, University of Utah, Salt Lake City, UT); Dominique Delbeke, MD (Vanderbilt University Medical Center, Nashville, TN); Vasken Dilsizian, MD (University of Maryland Medical Center, Baltimore, MD); Kent Friedman, MD (NYU School of Medicine, New York, NY); James R. Galt, PhD (Emory University Hospital, Atlanta, GA); Jay A. Harolds, MD (OUHSC-Department of Radiological Science, Edmond, OK); Aaron Jessop, MD (UT MD Anderson Cancer Center, Houston, TX); David H. Lewis, MD (Harborview Medical Center, Seattle, WA); J. Anthony Parker, MD, PhD (Beth Israel Deaconess Medical Center, Boston, MA); James A. Ponto, RPh, BCNP (University of Iowa, Iowa City, IA); Lynne T. Roy, CNMT (Cedars/Sinai Medical Center, Los Angeles, CA); Heiko Schoder, MD (Memorial Sloan-Kettering Cancer Center, New York, NY); Barry L. Shulkin, MD, MBA (St. Jude Children’s Research Hospital, Memphis, TN); Michael G. Stabin, PhD (Vanderbilt University, Nashville, TN); Mark Tulchinsky, MD (Milton S. Hershey Med Center, Hershey, PA).

XII. BIBLIOGRAPHY/REFERENCES


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**XIII. BOARD OF DIRECTORS APPROVAL DATES:**

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