

Procedure Guideline for Telenuclear Medicine 1.0*

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I. PURPOSE

The purpose of this guideline is to assist nuclear medicine practitioners in using telenuclear medicine for interpretation and consultation of nuclear medicine studies.

II. BACKGROUND INFORMATION AND DEFINITIONS

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

Because telenuclear medicine may allow more timely interpretation and facilitate consultation, it can provide improved health care. For example, it may enable increased availability of nuclear medicine in underserved areas. New uses for this evolving technology are likely to emerge.

Telenuclear medicine equipment is used to implement telenuclear medicine. The same equipment may be used for both on-site and telenuclear medicine. This guideline will focus on special considerations when nuclear medicine equipment is used at remote locations. Distribution of images in a single imaging center falls into the realm of picture archiving and communication systems (PACS) and is not the major focus of this document.

III. COMMON INDICATIONS

- A. To interpret routine studies at a remote location
- B. To interpret emergency studies in an on-call setting
- C. To provide consultation

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IV. PROCEDURE

A. Types of Telenuclear Medicine Systems

1. Telenuclear medicine can be implemented (a) using a nuclear medicine-only system; (b) as a part of a teleradiology 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 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 (e.g., using the X window protocol).
 - c. Using a special remote viewing station (e.g., using the World Wide Web or with installation of remote viewing software on a personal computer).

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 imaging.
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 telenuclear medicine application involves a limited range of procedures, then all functions needed to interpret or consult on these procedures should be provided.
2. The following general abilities facilitate remote viewing:

- a. Ability to simultaneously display comparison studies, with current and comparison data clearly identified.
 - b. Ability to adjust the size of the display windows.
 - 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.
3. The following abilities provide control of the display intensity:
 - a. Ability to display 8- or 16-bit data that may be scaled to 256 intensity levels for onscreen display.
 - b. Ability to adjust upper and lower levels interactively for each dataset.
 - c. Ability to determine the maximum pixel used for scaling. This will help avoid scaling artifacts resulting from too few gray levels when 16-bit data are scaled to 8 bits and very intense image artifacts (e.g., injection site) are present.
 - d. Ability to choose from a set of color tables.
 - e. Ability to apply lookup tables to adjust contrast.
 - f. Ability to add additional lookup tables.
 4. The following abilities facilitate planar image display:
 - a. Ability to display complete images ranging in size from 64×64 to 1024×1024 , including images that are not square and not powers of 2.
 - b. Ability to display a 1024×1024 or 512×1024 whole-body image centered within a smaller width frame (e.g., 256 pixels wide), intelligently trimming 0 or near-0 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., 1024×256) and spot images (e.g., 256×256).
 - 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.
 5. The following abilities facilitate dynamic image display:
 - a. Ability to cine a dynamic sequence, up to 256×256 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 thresholds and speed on each cine.
 6. The following abilities facilitate gated planar image display (radionuclide ventriculography):
 - a. Ability to cine at least 3 views (8–32 frames, 64×64 to 128×128 matrix size) at up to 1 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 at least 2 studies each with at least 3 views simultaneously.
 7. The following abilities will facilitate tomographic image display (PET and SPECT):
 - a. Ability to generate coronal and sagittal images for display from a transaxial dataset.
 - b. Ability to display multiple frames from a single axis, frames from all 3 axes, or an interactive multiaxis display.
 - c. Ability on the multiaxis display to display at least 1–3 transaxial slices, 1–3 coronal slices, 1–3 sagittal slices, and 1 cine, simultaneously.
 - d. Ability of the user to navigate the multiaxis display, including the ability to click on any plane with automatic adjustment of the other 2 planes to that position.
 - e. Ability to toggle cursors on and off on the multiaxis display showing the other image planes.
 - f. Ability to adjust slice thickness at time of display.
 8. 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 ability to adjust upper and lower levels, and apply color lookup tables to the processed screens, as described previously for other nuclear medicine images.
 9. Intra- and intermodality 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 smooth images (e.g., by a simple 9-point smooth) is recommended but not required.
 2. Other processing may be included as necessary for a specific remote application (e.g., displaying an activity profile).

E. Digitization

1. Modern nuclear medicine equipment is intrinsically digital. However, some legacy systems and archival systems still use film. Many of the correlative radiologic studies will be film based. Thus, most telenuclear medicine systems will require film digitization capabilities.
2. Specifications for digitization often will be dominated by correlative radiologic studies if the same digitizer is used for both nuclear medicine and correlative studies. (Note: many nonmedical transparency scanners [as opposed to film digitizers] do not have adequate dynamic range for image interpretation.)
3. Mass-market film digitizers can be used for nuclear medicine-only applications.
 - a. A common problem with mass-market digitizers is linear representation of the film optical density. Linear representation of optical density should be demonstrated over the full dynamic range of the film for both black-on-white and white-on-black formats. If color data are used, the digitizer must faithfully reproduce the color information.
 - b. Resolution is generally a less significant problem for nuclear medicine data. However, preservation of resolution in digitized data should be demonstrated.
 - c. Regular quality control of film digitizers should be performed. A segmented gray-scale pattern on film (e.g., the Society of Motion Picture and Television Engineers [SMPTE] pattern) can be used to verify the dynamic range of a film digitizer. A continuous grayscale pattern can be used to demonstrate the absence of "banding," to help ensure linearity of the digitization. Legibility of a small standard font (e.g., 5-point Times) might be used as a quick check of resolution of a digitized image.

F. 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 telenuclear medicine applications. Even analog telephone modem speeds are adequate for some on-call applications. In the on-call setting, correlative imaging requirements generally will dominate selection of a communication speed.

G. 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.

2. Compression can be either lossless, with the uncompressed data identical to the original, or lossy, with the uncompressed data altered from the original. If lossy compression is used, the remote data should be diagnostically comparable with the original.

H. Monitor Quality Control

1. Considerations

- a. The remote location may present special consideration for 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.
- c. Remote monitors, especially for on-call application, may have multiple uses, and the monitor setup may be altered by nonnuclear 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 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; line pairs of different widths should all be visible and have the same contrast (www.smpte.org/engineering_committees/medical.cfm).
- b. A test pattern, such as the SMPTE test pattern, may be used to check gray-scale linearity. For the SMPTE pattern, 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, change in intensity should be continuous without visible rings (<http://brighamrad.harvard.edu/research/topics/vispercep/tutorial.html>).
- d. The remote monitor should be checked visually for any gross color dysfunction (e.g., missing 1 of the R-G-B gun 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. There should be a regular protocol and schedule of quality control testing.

- b. In some multiuse settings, quality control may need to be tested for each telenuclear medicine session.
- c. Telenuclear medicine systems that show test pattern(s) at the time of log-in facilitate regular quality control.

I. 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 but to impede 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 to authorized individuals, both in transit and at the telenuclear medicine site. Security includes log-in, communications, and access to data stored on the remote system.
6. A time-out period may be implemented and should be appropriate for the environment in which the workstation is used.
7. It is anticipated that nuclear medicine is a low-priority target and that 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 log-in procedures and access to medical databases containing patient information than on encryption of pure image data.
8. There should be a disaster recovery plan dealing with breach of system security or loss of source data as a result of equipment malfunction.

V. ISSUES REQUIRING FURTHER CLARIFICATION

- A. The extent to which lossy compression provides diagnostically equivalent information when used either for primary interpretation or for correlative images needs further clarification.
- B. The legal issues dealing with remote interpretation need further development.

VI. CONCISE BIBLIOGRAPHY

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VII. DISCLAIMER

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high-quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different from the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend, in part, on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.