ACC, HIMSS and RSNA
Integrating the Healthcare Enterprise

IHE Radiology Technical Framework Supplement 2007-2008

Nuclear Medicine Image Profile NMI with Cardiac Option

Draft for Trial Implementation

Rev. 2.1

May 17, 2007

Contents

1. Foreword

Integrating the Healthcare Enterprise (IHE) is an initiative designed to stimulate the integration of the information systems that support modern healthcare institutions. Its fundamental objective is to ensure that in the care of patients all required information for medical decisions is both correct and available to healthcare professionals. The IHE initiative is both a process and a forum for encouraging integration efforts. It defines a technical framework for the implementation of established messaging standards to achieve specific clinical goals. It includes a rigorous testing process for the implementation of this framework. And it organizes educational sessions and exhibits at major meetings of medical professionals to demonstrate the benefits of this framework and encourage its adoption by industry and users.

The approach employed in the IHE initiative is not to define new integration standards, but rather to support the use of existing standards, HL7, DICOM, IETF, and others, as appropriate in their respective domains in an integrated manner, defining configuration choices when necessary. IHE maintain formal relationships with several standards bodies including HL7, DICOM and refers recommendations to them when clarifications or extensions to existing standards are necessary.

This initiative has numerous sponsors and supporting organizations in different medical specialty domains and geographical regions. In North America the primary sponsors are the American College of Cardiology (ACC), the Healthcare Information and Management Systems Society (HIMSS) and the Radiological Society of North America (RSNA). IHE Canada has also been formed. IHE Europe (IHE-EUR) is supported by a large coalition of organizations including the European Association of Radiology (EAR) and European Congress of Radiologists (ECR), the Coordination Committee of the Radiological and Electromedical Industries (COCIR), Deutsche Röntgengesellschaft (DRG), the EuroPACS Association, Groupement pour la Modernisation du Système d'Information Hospitalier (GMSIH), Société Francaise de Radiologie (SFR), Società Italiana di Radiologia Medica (SIRM), the European Institute for health Records (EuroRec), and the European Society of Cardiology (ESC). In Japan IHE-J is sponsored by the Ministry of Economy, Trade, and Industry (METI); the Ministry of Health, Labor, and Welfare; and MEDIS-DC; cooperating organizations include the Japan Industries Association of Radiological Systems (JIRA), the Japan Association of Healthcare Information Systems Industry (JAHIS), Japan Radiological Society (JRS), Japan Society of Radiological Technology (JSRT), and the Japan Association of Medical Informatics (JAMI). Other organizations representing healthcare professionals are invited to join in the expansion of the IHE process across disciplinary and geographic boundaries.

The IHE Technical Frameworks for the various domains (IT Infrastructure, Cardiology, Laboratory, Radiology, etc.) defines specific implementations of established standards to achieve integration goals that promote appropriate sharing of medical information to support optimal patient care. It is expanded annually, after a period of public review, and maintained regularly through the identification and correction of errata. The current version for these Technical Frameworks may be found at www.ihe.net/Technical_Framework.

The IHE Technical Framework identifies a subset of the functional components of the healthcare enterprise, called IHE Actors, and specifies their interactions in terms of a set of coordinated, standards-based transactions. It describes this body of transactions in progressively greater depth. The volume I provides a high-level view of IHE functionality, showing the transactions organized into functional units called Integration Profiles that highlight their capacity to address specific clinical needs. The subsequent volumes provide detailed technical descriptions of each IHE transaction.

This supplement to the IHE Radiology Technical Framework V7.0 is submitted for Trial Implementation in the 2007-2008 implementation and testing cycle.

Comments on this profile can be submitted to the IHE forums at
http://forums.rsna.org/forumdisplay.php?s=62281bf871e47a056870ee19d32bfae0&forumid=313

The IHE Radiology Technical Committee will address these comments and consider incorporation of this Trial Implementation supplement into the body of the Radiology Technical Framework in April 2008.

Date: May 17, 2007

Author: Jerold Wallis

Insertions to the current Radiology Technical Framework are mark as blue, underlined text; *deletions are marked as* ~~strikethrough text~~.

2. Introduction

This supplement proposes a change to the NM Image Profile. The major change is the addition of the Cardiac NM option to the NM Image profile, which is being requested by the IHE Cardiology committee to better meet cardiac needs. Since some of the existing portions of the NM profile do not apply to cardiac uses, the following reorganization was made:

Prior	Proposed
Basic NM Profile →	General NM Option*
Review Option →	(retired)
	Cardiac NM Option (new)*
	MPR Option (new)

* Image Display actors must choose at least one of General or Cardiac options.

This organization allows the bulk of the profile to be applicable to both general and cardiac nuclear medicine, while still allowing additional features for each separate category. The main item reserved for General NM is Whole Body Display. The main items specific to Cardiac NM are the ability to use MPR of two RECON TOMO short axis images to display them in the standard format approved by the American College of Cardiology (ACC NM Cardiac Display format).

Much of the content of the Review option was subsumed by the Cardiac NM option, but there was enough difference between them that it was felt best to retire the Review option and institute a new Cardiac option, rather than simply modifying the older Review option.

Additional tags were specified to identify attenuation corrected and prone SPECT images, to avoid misinterpretation of cardiac data.

Minor downgrades of requirements were made in the conversion of the Basic NM profile to the General NM Option, as reflected in Table 4.16-1. These represent features which on further consideration are non-essential.

The Comparison format has been eliminated, since one of the prior major uses was for cardiac display, and this use has been superseded by more specific cardiac formats. The other uses for a comparison format are not NM specific – the ability to compare two studies (e.g., by use of split screen or two-panel display) is no different than other radiology exams, and is now no longer specifically required in this profile.

2.1. Open Issues and Questions

1) How shall the information regarding optimum window level for cardiac data be conveyed from the evidence creator to the Image display? Such information is valuable, since the many evidence creators go through fairly elaborate routines involving isolating the myocardial contours and masking out activity from liver and bowel prior to determining best scaling for stress and rest images. Possibilities for sending this information include:

a) Storing the window levels in the DICOM header of the short axis data. However, this would require that window levels be known at the time the short axis data is saved to local storage. Because of the way processing is performed on nuclear medicine systems, it is frequently the case that the (reoriented) short axis data is stored by one program, and then another program analyzes the data, segments the images, and derives the window information. Unfortunately, modifying the header of the already-stored image data to include window information is strongly discouraged in DICOM.

b) Storing window levels in Presentation states. This is likely the preferred way to do this, but few (if any) nuclear medicine systems currently support presentation states, and requiring this now may impede adoption of the profile. Support for presentation states will likely become more common once the Image Fusion profile is adopted, since that profile requires use of the Blended Softcopy Presentation State. One might even consider use of the same object, since it includes pointers to two image objects, window level settings for each, alignment information (via a registration object), and a color table for display. However, use of simpler presentation state objects would likely be sufficient.

c) Leaving determination of window levels up to the Image Display (with the already required controls for adjusting them). This would be suboptimal for high volume use and for primary interpretation, since finding appropriate window levels is time consuming and incorrect choices may lead to interpretation error.

d) Allowing option (c) for now, and add (b) as a named option (either now or at a later point). As currently written, it is proposed that it be added as a future option.

2.2. Closed Issues

1) Shall the Cardiac NM Display be a separate Profile, or shall it be an option in the NM Image Profile? It shall be an option in the NM Image profile, since there is a great amount of overlap between the two.

2) Shall the ACC NM Cardiac Display be created from short axis images alone, or shall we require vertical long and horizontal long axis files to be sent as well to the image display? Image displays shall be able to construct the ACC display from the short axis images only. The requirements for orthogonal multi-planar reconstruction are small with respect to the display requirements, and transmission of only short axis data will simplify

data flow, storage, and retrieval, as well as avoid possible errors due to viewing of inconsistent data.

3) (Removed)

4) Will the Cardiac Image option require the Result Screen Export Option? No. While the export of result screens such as Bull's-eye images is desirable for cardiac imaging, there are no other requirements for the Evidence Creator that are specific to the Cardiac Option, and thus the Cardiac Option does not exist for evidence creators. This makes it impossible to link the two, even if that were desirable. Thus, for full functionality, users should request the "Cardiac Option for Image Displays" and the "Result Screen Export Option for Evidence Creators".

5) Should the description of the ACC NM Cardiac Display reside in volume 1, or in a volume 2 appendix, or in the body of volume 2? It shall be in the body of volume 2, as it has specific requirements relevant to the profile.

6) Will this option be a change proposal to final text, or shall it be submitted as a supplement for trial implementation? This represents a significant addition to the NM Image Profile. Publication for trial implementation will not impede testing at the Connectathon, and will allow more time for vendor feedback.

3. Profile Abstract

This change to the NM Image Profile is designed to improve functionality for nuclear medicine cardiac image viewing, and is being made at the request of the Cardiology Technical Committee. Specific items address in the profile include synchronous viewing of several gated images or several projections of tomographic images, and ability to display myocardial perfusion data in the standard accepted format with customary abilities for the user to manipulate the data at time of display. Previously, the profile relied on save-screens (secondary capture objects) for myocardial perfusion display, and these did not have sufficient functionality for reliable image interpretation.

4. GLOSSARY

ACC NM Image Display – A display format for myocardial perfusion studies approved by the American College of Cardiology and the Society of Nuclear Medicine, as detailed in RAD TF-1: E.5.3.3 and RAD TF-2: 4.16.4.2.2.

Volume I – Integration Profiles

1. Changes to sections 1 – 1.X

1.7 2006 – 2007 (Year 8) Scope Additions

The following changes have been made to the Nuclear medicine Image Profile

- The image display requirements of the prior basic Image NM profile have been moved to the General NM Option.
- The requirement for a comparison display has been removed from the General NM Option.
- A new Cardiac NM Option has been added.
- Image display actors must claim either the General NM Option or the Cardiac NM Option or both. (Image Display actors which previously qualified under the Nuclear Medicine Image profile can claim support for the General NM Option of the Nuclear Medicine Image Profile.)
- The Review option has been retired
- A new MPR option has been added.

1.8 2007 – 2008 (Year 9) Scope Additions

The following changes have been made to the Nuclear medicine Image profile with cardiac option

- Requirements for frame selection were made simpler, to allow vendors more flexibility in meeting those requirements.

16. NM Image Integration Profile

The NM Image Profile specifies how NM Images are to be stored by Acquisition Modalities and Evidence Creator workstations and how Image Displays should retrieve and make use of them.

It defines the basic display capabilities Image Displays are expected to provide, (such as might be sufficient for a referring physician) but does not address advanced review features.

~~It~~ The profile also defines how result screens, both static and dynamic, such as those created by NM Cardiac Processing Packages, should be stored using DICOM objects that can be displayed on general purpose Image Display systems.

The profile does not address advanced processing functions typically found on dedicated NM workstations.

The NM Image Profile can be enhanced by combining it with other workflow profiles such as Scheduled Workflow, Post-Processing Workflow and Reporting Workflow which address how to schedule, manage and report the status of the steps in which NM Image objects are created.

16.2 NM Image Integration Profile Options

Options that may be selected for this Integration Profile are listed in the table 16.2-1 along with the Actors to which they apply. Dependencies between options when applicable are specified in notes.

Table 16.2-1 ~~Evidence Documents~~ NM Image Profile - Actors and Options

Actor	Options	Vol & Section
Acquisition Modality	*No options defined*	
Evidence Creator	*Result Screen Export Option*	RAD TF-2: 4.18.4.1.2.4 RAD TF-2: 4.16.4.2.2.4
Image Archive/Manager	*No options defined*	
Image Display	*~~Review~~* *MPR Option* *General NM Option** *Cardiac NM Option**	 RAD TF-2: 4.16.4.2.2.~~2~~3.5 RAD TF-2: 4.16.4.2.2.3.6 RAD TF-2: 4.16.4.2.2.3.7

*Image Display actors shall support the General NM Option, the Cardiac NM Option or both.

~~The NM Image Profile is designed to provide faithful and complete storage and retrieval of NM data and sufficient display functionality to allow adequate review of nuclear medicine images by referring physicians. It should also be sufficient for secondary review (without reprocessing capability) of cardiac nuclear medicine studies by cardiologists and for correlation of nuclear medicine images with other imaging modalities during review by general radiologists.~~

~~The Review Option is intended to add functionality for primary (non-cardiac) NM interpretation.~~

The Cardiac NM Option defines functionality for cardiac NM interpretation.

The General NM Option defines functionality for whole body imaging and other non-cardiac NM interpretation.

The Result Screen Export Option adds functionality for storing Result Screens (which may be static or may contain moving components) in commonly displayable DICOM formats.

The MPR Option adds multi-planar reconstruction of SPECT (RECON TOMO) images for the Image Display, and is intended for non-cardiac use. Thus, it adds functionality to Displays that support the General NM Option.

~~Acquisition Modality actors which support Result Screen Export should claim the appropriate options as an Evidence Creator.~~

~~Processing functions of both cardiac and non-cardiac data are not addressed in this profile, and should be performed on a dedicated NM workstation.~~

Appendix E.5.2 Clinical Examples

…

In general, typical display formats for each of the NM Image Types would be as follows:

STATIC: Simple display. Typically several images displayed at once (for example in a Fit display). While the default order of frames in the object is sorted by Energy Window then Detector, it is generally more useful to present them in Detector/Energy Window order or sorted by acquisition time. Example: 12 view static

WHOLE BODY: Side by side display of two rectangular images (i.e. the Whole body display).

DYNAMIC: Cine through all frames of all phases from one detector and one energy window, in order. It is also useful to display in a Grid ~~or Row~~ display. Generally a different window level applies to each phase. Processing (not required by the NM profile) includes plotting time activity through user selected areas of the image.

GATED: Cine through the frames from one detector/energy window, in time order. Processing (not required by the NM profile) can include time activity curves, heart wall edge detection and motion tracking, etc. Typically several images displayed at once.

TOMO: Cine all frames from one (logical) detector in rotational angle order. Recommend ability to cine back and forth (i.e., frames 1 to n, followed by frames n to 1), in addition to the standard forward cine.

RECON TOMO: Display all slices in spatial order. Typical display actions can include reorientation to other viewing planes (MPR). Processing (not required by the NM ~~Option~~ Image Profile) can include oblique reorientation to cardiac relative views, creation of MIP images, etc. ~~Example: Stress-Rest in a Row Layout display, or a single dataset in an MPR Display.~~

GATED TOMO: Cine all frames (angular views) from one energy window, one (logical) detector, one rotation, one R-R interval, and one Time Slot, or all Time Slots from one energy window, detector, rotation, R-R interval, and Angular View. Some users do not review these images unless data acquisition problems are suspected.

GATED RECON TOMO: ~~Cine all frames from one R-R Interval and one Time Slot~~. Display images in ACC NM Cardiac Display, with ability to cine the images. Typical processing includes ~~all functions done to RECON TOMO images, plus~~ special cardiac processing such as bull's-eye plot creation and wall motion analysis.

Appendix E.5.3.1 Example Layouts

Comparison Display (2 Framesets)

A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8

or alternatively,

A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
A_9	…	…	…	…	…	…	A_{16}
B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
B_9	…	…	…	…	…	…	B_{16}

Another form of comparison display might involve using two monitors or a single monitor screen split in half.

A_1	A_2	A_3	…	B_1	B_2	B_3	…
…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…
…	…	…	A_{16}	…	…	…	B_{16}

Note that Comparison displays are not specifically required by the NM Image profile.

Appendix E.5.3.2 Clinical Examples

This section provides examples and clarifications on typical patterns of display for NM Images.

This section should not be considered as an attempt to address hanging protocols. This is a complex topic which DICOM is working on. Once that work is complete, NM and Radiology in general would benefit from that work being included in the IHE Framework. This section is not intended to supplant that.

See RAD TF-2: 4.16.4.2.2.3 for a description of some of the display related capabilities referred to in these examples.

Example 1a: Cardiac Study (using the General NM Option)

The user selects a Tomo stress series, ~~several static result screens (secondary captures),~~ another Tomo rest series, several static result screens (secondary captures), and a dynamic result screen (multiframe secondary capture).

The user would like to see both Tomo images together ~~in a Row Display and be able~~ to view them synchronously in Cine display, preferably with a method for adjusting the cine speed.

Next the user would like to step forward and backward through each of the secondary capture result screens (which may be stored in a set of Secondary Capture images or in a single Multi-Frame Secondary Capture image without a cine module).

The user would also like to review the dynamic result screen in cine mode. It is useful to be able to adjust the cine speed. Systems unable to cine the result screen at 8 frames/sec or faster would have limited clinical usefulness.

Example 1b: Cardiac Study (using the Cardiac NM Option)

The user selects a Tomo (or Gated Tomo) stress series and a Tomo (or Gated Tomo) rest series. The user would like to see both Tomo images together to view them synchronously in Cine display, preferably with a method for adjusting the cine speed. If one of the images is a gated tomo, the user may want to turn off the gated part by selecting only the first time slice of the sequence.

The user selects two Recon Tomo short axis data sets (stress and rest), and would like to see them displayed in ACC NM Cardiac Display, so that he can compare short axis data, horizontal long axis data, and vertical long axis data. The user notes the slices are not exactly aligned, and takes advantage of the capability to slide one slice set (e.g., adjusting the stress short axis slice position to the left) to better align them. The use notes that the stress slices are not optimally scaled, and takes advantage of the capability to adjust the upper level of the entire stress image data set, leaving the rest unchanged. The user is then unsure about one area, and decides to adjust the lower level of both data sets simultaneously to view the images with a 20% background subtraction (without changing the upper levels). A colleague walks into the room and wishes to view the entire screen (rest and stress) in a different color table that is already installed locally on the display, and the user is able to make this change.

The user selects one or two Recon Gated Tomo short axis data sets, to assess wall motion in cine format, again with the ability to view horizontal and vertical long axis images as well due to the MPR capability.

The user selects several static result screens (secondary captures). The user would like to step forward and backward through each of the secondary capture result screens (which may be stored in a set of Secondary Capture images or in a single Multi-Frame Secondary Capture image without a cine module).

The user may also select a dynamic result screen (multiframe secondary capture). In such cases, the user would also like to review the dynamic result screen in cine mode. It is useful to be able to adjust the cine speed. Systems unable to cine the result screen at 8 frames/sec or faster would have limited clinical usefulness.

Add section E.5.3.3

Appendix E.5.3.3 The ACC NM Cardiac Display

The ACC NM Cardiac Display is a display format for viewing of stress and rest tomographic nuclear medicine myocardial perfusion images.

This format was adopted by the American Heart Association, the American College of Cardiology, and the Society of Nuclear Medicine and published as, "Standardization of Cardiac Tomographic Imaging" in the journals of all three organizations.

Circulation. 1992 Jul;86(1):338-9
J Am Coll Cardiol. 1992 Jul;20(1):255-6
J Nucl Med 1992 33: 1434-1435

The reader is encouraged to refer to the original documents for further information. Specific implementation requirements can be found in Volume 2, section 4.16.4.2.2.3.2.

To facilitate transfer and display of cardiac data, several digital conventions and DICOM attributes have subsequently been developed. When data is sent from one system to another, the short axis data are sent, and the other two planes are generated on-the-fly. DICOM attributes to designate the cardiac slice orientations have been created, as documented in Table 4.8-2.1.

When comparing two data sets, it is essential that the user know which are stress and which are rest data. DICOM attributes to designate the patient state have been created, as documented in Table 4.8-2.2.

Typically two data sets are compared, with the stress state images displayed in a row above the second data set (which can either be resting, reinjection, redistribution, or delayed redistribution). If two data sets are displayed and no stress images are present, then the resting data set is typically displayed as the upper data set, and the second data set (reinjection, redistribution, or delayed redistribution) is displayed below.

The most common use is to display two data sets (stress and rest). Occasionally, only a single data set is displayed. Occasionally, 3 or more data sets are displayed. A typical display format is depicted below in Table E.5-2, as an illustrative example. The stress and rest images are interleaved in alternate rows, with corresponding short axis, vertical long axis, and horizontal long axis slices above/below each other, as recommended in the ACC format. Many displays choose to have two rows of short axis data as shown here, since given the shape of the heart, there are more short axis images of interest than long axis images. In this example, data set A are Stress images, and data set B are Rest images.

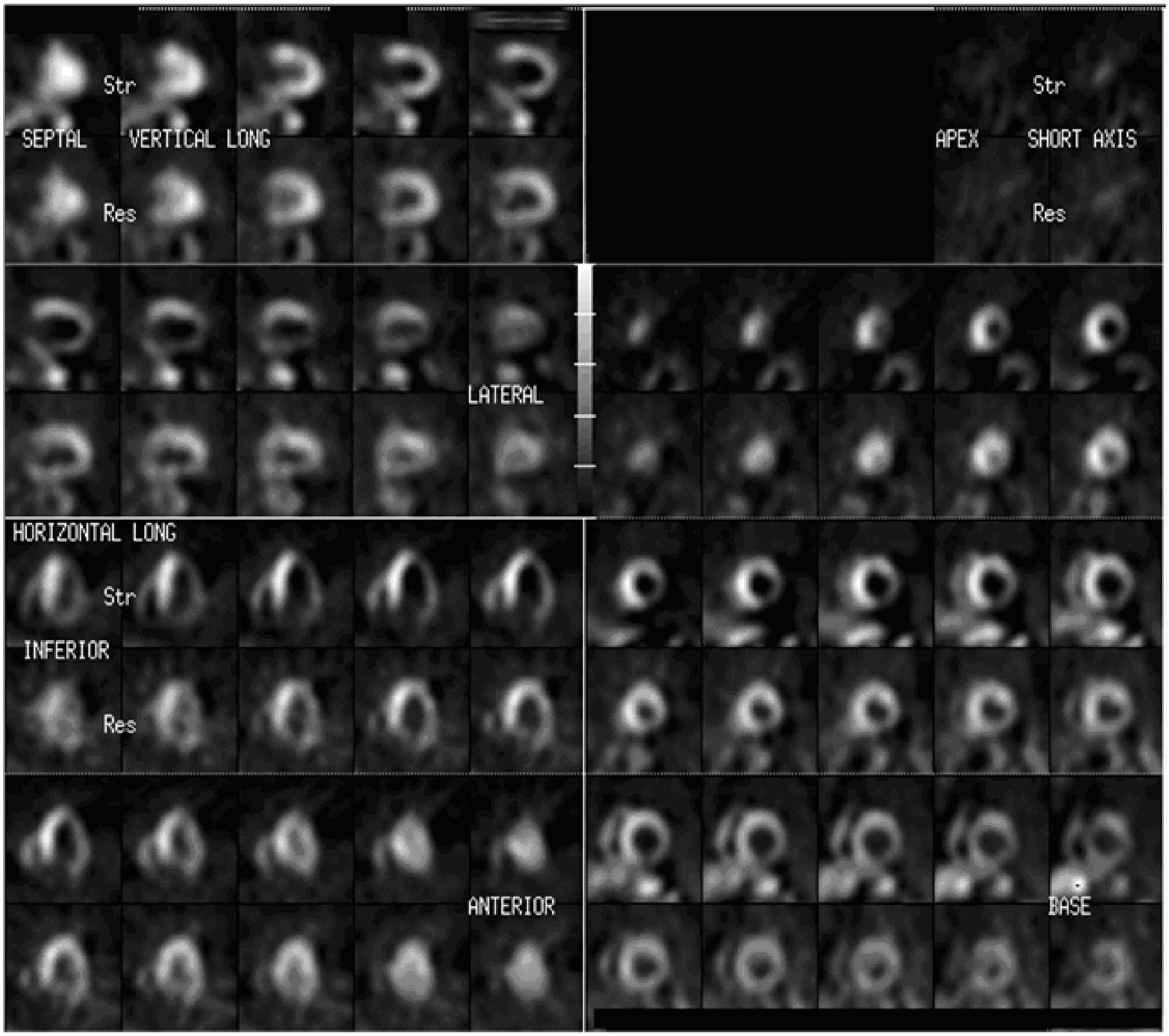
In the example layout shown in Table E.5-2, it can be seen that 16 stress short axis slices are displayed (A-s1 through A-s16). In fact, there may be more than 16 slices in the short axis data set. In such cases, it is common practice to center the slices within the display (i.e., omit an equal number of initial and trailing slices) when initially presenting them to the user, while allowing the user to subsequently "slide" the slices to reveal the other slices as desired. This holds true for the other (long axis) views as well.

Stress Short	A-s_1	A-s_2	A-s_3	A-s_4	A-s_5	A-s_6	A-s_7	A-s_8
Rest Short	B-s_1	B-s_2	B-s_3	B-s_4	B-s_5	B-s_6	B-s_7	B-s_8
Stress Short (continued)	A-s_9	A-s_{10}	A-s_{11}	A-s_{12}	A-s_{13}	A-s_{14}	A-s_{15}	A-s_{16}
Rest Short (continued)	B-s_9	…	…	…	…	…	…	B-s_{16}
Stress Vertical	A-v_1	…	…	…	…	…	…	A-v_8
Rest Vertical	B-v_1	…	…	…	…	…	…	B-v_1
Stress Horiz.	A-h_1	…	…	…	…	…	…	A-h_8
Rest Horiz.	B-h_1	…	…	…	…	…	…	B-h_8

Table E.5-2

Another example layout, which also meets the ACC NM Cardiac Display standards, is shown in Figure E.5-3. While Table E.5-2 (above) shows the more commonly used approach and would be more familiar to most viewers, the non-commercial example shown in Figure E.5-3 (below) illustrates that other conforming layouts are possible. It can be seen in this example that all the short axis slices are placed on the right-hand side of the display. Again, the rows of stress and rest images are interleaved, and the short axis slices are marked as going from apex to base. The vertical and horizontal long axis slices appear on the left side of the display, and are similarly interleaved and labeled. Note that in the horizontal long slices, the frames have been rotated 90 degrees so that the apex points up, as per ACC standards. This helps the viewer immediately distinguish the vertical long axis slices from the horizontal long axis slices, since if this rotation were not performed, the slices would appear quite similar.

Figure E.5-3



Note that users may desire to separately adjust the upper/lower level display settings of only the first data set, only the second data sets, or they may desire to change the display setting for both data sets simultaneously. Note also that the images may not be properly aligned as they are initially presented to the user, and the user will then want the ability to “slide” images in each row to the left or right to properly align them. Finally, users may wish to apply a color palette to these grayscale images to view them as a “pseudocolor” display.

While the ACC format does not specify how GATED RECON TOMO images be displayed, the following provides a guide based on current convention. When GATED RECON TOMO images are selected for display in ACC format, they will typically be displayed in the same orientation and format as above, initially displaying one of the time slots, but with the ability to turn the cine on. An alternative format when “cine” is selected is to have the display "pick" 3 short axis slices (apical, mid and basal short axis) along with a mid vertical and mid horizontal axis gated SPECT slices and display them in a five image display. It is not clear which is preferred: to load and gate all of the slices or to have the software select and gate certain slices. In the latter case, the user might want to have some control on the selection process.

Note that when selecting two (Stress and Rest) datasets, the user may pick a RECON TOMO dataset for one and a GATED RECON TOMO dataset for the other. In such case, the software may provide an option to “sum” or “collapse” the GATED RECON TOMO dataset to display it as if it were an ungated image, though this capability is not required under the profile.

Volume II – Transactions

4.8 Modality Images Stored

In Volume 2, Section 4.8.4.1.2.2 is modified as below.

4.8.4.1.2.2 Storage of NM Images (NM)

Systems supporting the NM Image Profile are required to support a number of attributes as described in the following tables and text. Although ~~M~~many of these ~~requirements~~ ~~build on~~ attributes ~~which~~ are Type 2 or Type 3 in DICOM, ~~(such~~ attributes ~~are~~ indicated with R+~~)~~ shall be present and shall have a value.

This section is referred to in the Creator Images Stored transaction (Section 4.18) and so the Evidence Creator actor may also be referred to in the text here.

Table 4.8-2. Required Attributes in Nuclear Medicine Images

Attribute	Tag	Image Type									
		General						Cardiac			
		STATIC	DYNAMIC	WHOLEBODY	GATED	TOMO	RECON TOMO	TOMO	RECON TOMO	GATED TOMO	RECON GATED TOMO
Detector Information Sequence	(0054,0022)										
> Image Position	(0020,0032)						R+		R+		R+
> Image Orientation	(0020,0037)					R+	R+	R+	R+	R+	R+
> View Code Sequence	(0054,0220)										
>> Code Value	(0008,0100)			R+					R+[1]		R+[1]

		Image Type									
>> Coding Scheme Designator	(0008,0102)			R+					R+[1]		R+[1]
Slice Progression Direction	(0054,0500)								R+[2]		R+[2]
Spacing Between Slices	(0018,0088)						R+[4]		R+[4]		R+[4]
Acquisition Context Sequence	(0040,0555)										
> Concept-Name Code Sequence	(0040,A043)							R+[3]	R+[3]	R+[3]	R+[3]
> Concept Code Sequence	(0040,A168)							R+[3]	R+[3]	R+[3]	R+[3]
Corrected Image	(0028,0051)						R+[5]		R+[5]		R+[5]
Patient orientation code sequence	(0054,0410)										
> Patient orientation modifier code sequence	0054,0412)					R+	R+	R+	R+	R+	R+

Note 1: Required for images from one of the standard cardiac views: Short Axis, Vertical Long Axis, or Horizontal Long Axis. For a definition of these terms and the implied orientation of the heart in the frame (refer to Nuclear Cardiology Nomenclature, Cequeria MD, et al, Journal of Nuclear Cardiology, 2002, 9:240-245). The Code Values shall be taken from Context ID 26 (relevant codes are shown here):

Table 4.8-2.1

Coding Scheme Designator	Code Value	Code Meaning
SNM3	G-A186	Short Axis
SNM3	G-A18A	Vertical Long Axis
SNM3	G-A18B	Horizontal Long Axis

Note 2: Slice Progression Direction is required for Images in which the View Code Sequence indicates Short Axis views. The DICOM defined values are APEX_TO_BASE and BASE_TO_APEX.

Note 3: The Acquisition Context Module (introduced to the NM IOD in CP-351) and the Acquisition Context Sequence (0040,0555) contained within it are required for cardiac stress/rest images. As defined in the Standard, the Concept Name Code Sequence (0040,A043) shall contain (DCM, 109055, "Patient State") and the Concept Code Sequence (0040,A168) shall use values from the following list:

Table 4.8-2.2

Coding Scheme Designator	Code Value	Code Meaning
SRT	F-01604	Resting State
DCM	109091	Cardiac Stress State
DCM	109092	Reinjection State
DCM	109093	Redistribution State
DCM	109094	Delayed Redistribution State

Note 4: The ‘Spacing between Slices’ attribute is required by IHE to contain a valid value for the RECON image types.

Note 5: Corrected Image (0028,0051) shall be present, with one of the values being ATTN, when storing attenuation corrected data. It may be present otherwise.

It is recommended that when multiple energy windows are present that descriptive values be provided for the following attributes: Energy Window Name (0054,0018), Energy Window Lower Limit (0054,0014) and Energy Window Upper Limit (0054,0015).

If preferred window level settings based on activity within myocardial contours are known at the time of creation of cardiac short axis images, the information may be stored in Window Width (0028,1051) and Window Center (0028,1050). It is likely that use of presentation states will become the preferred method for storing this information in a future revision of the profile.

4.16 Retrieve Images

In Volume 2, Section 4.16, the entire Table 4.16-1 and the notes following it are replaced as below.

Note to editor – the black underlines in the Required Frame selection column should remain as underlines in the final document. New text is shown in blue for the convenience of the reader, but for clarity, deletions are not shown, and the entire table should be replaced in the TF.

Additional changes to the immediately following text in 4.16.4.2.2.3.1 are also noted.

Table 4.16-1. Selection, Sorting and Viewing Requirements for NM Images

Image Type (0008,0008) Value 3	Frame Increment Pointer (0028,0009) [i.e. vectors]	Required Frame Selection [1] E = single **E** = all	Display Capabilities (See 4.16.4.2.2.3.2)	# of Simultaneous Framesets	
				General NM Option	Cardiac NM Option
STATIC	Energy Window (0054,0010) Detector (0054,0020)	**E D** See Note 2 E **D**	Grid Display	1	1
			Fit Display	12	12
WHOLE BODY	Energy Window(0054,0010) Detector(0054,0020)	**E D** See Note 2 E **D**	Whole body Display	2	-
DYNAMIC.	Energy Window (0054,0010) Detector (0054,0020) Phase (0054,0100) Time Slice (0054,0030)	**E D P T** See Note 3 E D P **T** E D **P T**	Grid Display	1	1
			Cine	1	1
GATED	Energy Window (0054,0010) Detector (0054,0020) R-R Interval (0054,0060) Time Slot (0054,0070)	**E D I T**	Grid Display	1	1
			Cine	3	6
TOMO	Energy Window (0054,0010) Detector (0054,0020) Rotation (0054,0050) Angular View (0054,0090)	**E D R A**	Grid Display	1	1
			Cine	3	3
GATED TOMO	Energy Window(0054,0010) Detector (0054,0020) Rotation (0054,0050) R-R Interval (0054,0060) Time Slot (0054,0070) Angular View (0054,0090)	**E D R I T A** The following are optional: **E D R I T** A **E D R I** T **A**	Grid Display	1	1
			Cine	1	3
RECON TOMO	Slice (0054,0080)	**S**	Grid Display	1	1
			ACC NM Cardiac Display		2
GATED RECON	R-R Interval (0054,0060)	**I T S**	Grid Display	1	1

				# of Simultaneous Framesets	
TOMO	Time Slot (0054,0070) Slice (0054,0080)	**See Note 4** **I** **T** S **I** T **S**	ACC NM Cardiac Display with Cine		2

Note 1: The Frame Selection column refers to the Frame Increment Pointer vectors by their first letter (except for R-R Interval which uses "I" for Interval). A letter shown underlined and bold (e.g. **E**) indicates that all values for that vector are selected. A letter shown in plain text (e.g. E) indicates that a single value for that vector has been selected. So in the case of the TOMO Image Type, **E R D A** means that all frames of the image are selected; while E R D **A** means that the selected frames represent all Angular Views for a specific Energy Window, a specific Detector and a specific Rotation. **For all image types, the ability to select and display all frames is required. For some image types, the ability to select subsets of frames (framesets) is required, as indicted in the table, in order to selectively adjust window levels or to limit the display to only that subset of images. It is preferable that this selection be performed by allowing the user to select frames based on the image vector information (eg, selecting the "Technetium" energy window in a dual energy study, or selecting the "Anterior" images in a dual detector dynamic study). However, as specified in Notes 2-4 below, alternate methods that achieve the same goals are acceptable.**

Note 2. In the case of a static or whole body image containing frames from two energy windows, the intensity of the two sets of frames may be very different, and some method to allow separate windowing of the two datasets is required in order to view them both simultaneously. This may be done by any suitable method, including allowing the user to explicitly select the frames from one energy window for subsequent windowing, allowing the user to select arbitrary individual frames for windowing, etc,

Note 3. In the case of images containing dynamic frames from two detectors, it would be confusing for them to be displayed as a single dynamic cine (since it would flip back and forth between the two detectors). Therefore, some method of selecting a frameset for viewing purposes shall be provided. This may be done by any suitable method, including allowing the user to explicitly select the frames from one detector or orientation for display, allowing the user to select arbitrary consecutive frames for cine, showing anterior and posterior data as separate side-by-side cines, etc. Ability for the user to select specific phases of the study is also recommended, but not required. Note that orientation labels (such as Anterior/Posterior Right/Left) should be shown if the information is available, as noted in the final paragraph of E.5.3.2.

Note 4. Display of cardiac slice data at a single part of the cardiac cycle such, as display of end-diastolic and end-systolic frames (I T S), and display of slices in cine mode showing the heart beating (I T S) are required only under the Cardiac NM Option, and would likely be part of a dedicated cardiac display.

4.16.4.2.2.3.1 Frame Selection Support

In most cases, a user will likely wish to select all the frames in an image for display or other manipulation—in such cases the frameset consists of all the image frames. However, for specific types of images, it is useful to be able to select a smaller subset of frames within a single image as a frameset for subsequent display or manipulation. The preferred method of selecting framesets is by image vector (though other methods of achieving the same goals are acceptable as detailed in the notes following Table 4.16-1). When selecting framesets by vectors, a ~~A~~ Frame Selection consists of either a single value, or “all values” being identified for each vector in the Image. In fact (except for the case of selecting “all frames” and and the case of selecting all phases and time slices in a Dynamic Image) a single value will be identified for all but one of the available vectors.

4.16.4.2.2.3 Display of NM Images

The contents of this section are required for Image Displays claiming the NM Image Profile.

The following requirements are intended to establish a baseline level of capabilities. ~~Providing more intelligent and advanced capabilities is both allowed and encouraged.~~ The intention is to focus on display capabilities, not to dictate implementation details.

Some examples of display behavio~~u~~rs typical to NM are described in RAD TF-1, Appendix E.5.3.

The NM Image IOD is a multi-frame image indexed by vectors as described in Section 4.8.4.1.2.2.1. “Image” will be used here to strictly refer to the IOD, while frame will be used to refer to the usual two-dimensional array of pixels.

The Image Display shall be able to display the frames in the order they are stored in the image.

The Image Display shall be able to perform the frame selections shown for each Image Type in the Table 4.16-1 and as described below in 4.16.4.2.2.3.1 Frame Selection Support. The result of a frame selection will be referred to as a “frameset” in this document. Note that a frameset only references frames from a single Image.

The Image Display shall be able to display simultaneously multiple framesets. These may be from the same Image, different Images, different Series, or different Studies.

The Image Display is not required to display simultaneously multiple framesets with different Image Types. ~~(Note that two exceptions to this are identified in 4.16.4.2.2.3.5 Review Option).~~

The Image Display shall be able to display simultaneously at least the number of framesets indicated in table 4.16-1.

4.16.4.2.2.3.2 Display Capabilities

In Volume 2, Section 4.16.4.2.2.3.2 Display Capabilities, the section on comparison display is removed.

~~Comparison Display~~

~~For Comparison Display, the Image Display shall display several framesets simultaneously in a fashion such that frames in the two framesets can be compared. For example, each frameset could be placed on an adjacent row.~~

~~Display of each frameset in a single row (i.e. the number of rows equals the number of framesets) is required. Support for more than one row per frameset is optional. Comparison requires that the relationship between frames in the two framesets be maintained when navigating, and to be adjusted separately/established.~~

In Volume 2, Section 4.16.4.2.2.3.2 Display Capabilities, MPR is no longer referenced in table 4.16-1 so the section on MPR (Multiplanar Reconstruction Display is removed. A new section on ACC NM Cardiac display is added following cine display.

~~MPR (Multi-Planar Reconstruction) Display~~

~~For MPR Display, the Image Display shall provide MPR capabilities for slice stack data. Typically, MPR involves displaying three orthogonal plane views at the same time along with a method of navigating the volume (i.e. controlling the specific sagittal, coronal and transaxial images shown).~~

~~The Image Display is not required to generate oblique slices from slice data, but is required to generate orthogonal slices even if the slice data is obliquely oriented.~~

~~In the NM Image Profile, MPR Display shall be supported when claiming the Review Option (See section 4.16.4.2.2.3.5). When displaying NM Data, the Image Display shall be specifically capable of taking a frameset of slice data from a RECON TOMO or GATED RECON TOMO image and displaying all three orthogonal plane views (transaxial, sagittal and coronal). PET transaxial data in the MPR display is strongly encouraged, but not required under the NM Profile.~~

~~Refer to DICOM documentation for details on how orientation and spatial information is encoded in the NM Image IOD.~~

Cine Display

The Image Display shall be able to display a cine of the selected frames as indicated by the order they are stored in the Image.

The Image Display shall be capable of displaying cines of multiple framesets simultaneously as indicated above in Table 4.16-1.

When the framesets have the same number of frames, the Image Display shall be capable of displaying the cines in synchronization (i.e. the first frame of each frameset should display simultaneously, the second frame of each frameset should display simultaneously, etc.).

The Image Display shall provide the ability to adjust intensity (as described below in Section 4.16.4.2.2.3.3) for each frameset independently.

ACC NM Cardiac Display

For ACC NM Cardiac Display, the Image Display shall meet the following requirements. (Additional information regarding this standardized display can be found in Volume 1 section E.5.3.3.)

The Image Display shall be capable of taking a cardiac short axis data set and generating the corresponding vertical long axis, and horizontal long axis data sets.

For each axis, multiple frames are displayed, in a left-to-right (preferred) or top-to-bottom format.

When two SPECT image sets are compared, they should be displayed simultaneously as a series of frames, either one above the other (preferred) or one next to the other.

Short axis data shall be displayed as serial frames with the apical slices first, progressing from the cardiac apex to the base of the heart. The heart shall be displayed with the following orientation:

Anterior wall
Septum (heart) Lateral wall
Inferior wall

Vertical long axis data shall be displayed as serial frames with the septal slices first, progressing to the lateral wall. The heart shall be displayed with the following orientation:

Anterior wall
Base (heart) Apex
Inferior wall

Horizontal long axis data shall be displayed as serial frames with the inferior slices first, progressing to the anterior wall. The heart shall be displayed with the following orientation:

Apex
Septum (heart) Lateral Wall
Base

Short axis slices shall be labeled to convey they are “Short axis, apex to base”.

Vertical long axis slices shall be labeled to convey they are “Vertical long axis, septal to lateral”.

Horizontal long axis slices shall be labeled to convey they are “Horizontal long axis, inferior to anterior”.

Images with the value of "ATTN" (i.e. Attenuation Corrected) in Corrected Image (0028,0051) shall be labeled as such.

Images with the value of "prone" in the Patient Orientation Modifier Code Sequence (0054,0412) shall be labeled as such.

The Image Display shall allow the user to window the Stress data independently of the Rest data, such that windowing affects all displayed Stress frames in the short and long axis views.

The Image Display shall allow the user to window the Rest data independently of the Stress data, such that windowing affects all displayed Rest frames in the short and long axis views.

The Image Display shall allow the user to window both Stress and Rest simultaneously in a manner that preserves the relative scaling of the two datasets. In other words, when both images are selected and the desired window is changed, the changes shall occur in a proportional manner for each image.

Example: The stress image is displayed with a window settings of (0,100), corresponding to the lower and upper window levels. The rest image is displayed with window settings of (0,50). The user adjusts the stress upper level to yield a window setting of (0,120). The user then selects both the stress and rest images, and adjusts the windowing to perform a 10% background subtraction on both images simultaneously, resulting in (12,120) for the stress image set, and (5,50) for the rest image set. Thus the relative scaling of the two images is preserved during this last adjustment.

If values for Window Width (0028,1051) and Window Center (0028,1050) are present in the short axis data, they may be used to determine initial window settings at time of display. It is likely that use of presentation states will become the preferred method for conveying this information in a future revision of the profile.

The Image Display shall allow the user to adjust the Stress and Rest frame positions so that corresponding frames are displayed. This typically appears as sliding one row of frames to the right or to the left.

The display order of the data sets is critical for interpretation. Regardless of the order in which the data sets were selected by the user, the display order in the ACC NM Cardiac Display shall be determined by the Patient State (see Note 3 in section 4.8.4.1.2.2). The display order for different Patient State values is as follows:

1) Cardiac Stress

2) Resting, Reinjection

3) Redistribution

4) Delayed Redistribution

If the user selects two data sets with the same Patient State, the display order is undefined.

The value of Patient State for each data set shall be displayed.

Examples: A typical set of cardiac images will include one "Cardiac Stress short axis image", and because it has highest precedence in the above list, it is placed into the first image position in the ACC NM Cardiac Display. Images are typically selected in pairs, and the pair of selected data sets will typically include a Cardiac Stress data set, which is therefore placed in the first position ("Stress") in the ACC NM Cardiac Display, and a Cardiac Rest data set, which is placed in the second position ("Rest") in the ACC NM Cardiac display. If the selected data sets consist of only a rest image and a redistribution image, then the rest image is placed into the first position, since it has the highest precedence.

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4.16.4.2.2.3.5 ~~Review Option~~ MPR Option

Image Displays claiming the ~~Review~~ MPR Option shall support the following Multi-Planar Reconstruction display capabilities in addition to those indicated in Table 4.16-1.

~~The Image Display shall be capable of displaying both a Dynamic Image frameset and Static Image frameset(s) at the same time.~~

~~The Image Display shall be capable of displaying both a Wholebody Image frameset and a Static Image frameset at the same time (i.e. anterior & posterior wholebody and several static spot images).~~

~~The Image Display shall be capable of displaying the pixel value of a selected pixel.~~

The Image Display shall be capable of resampling a set of slices to generate orthogonal slices in the other two planes (e.g. generating coronal and sagittal slices from a set of transverse slices).

The Image Display shall support viewing of three orthogonal plane views at the same time and shall provide a method of navigating the volume (i.e. controlling the specific sagittal, coronal and transverse images shown). Examples of MPR Displays can be found in Volume 1, Appendix E.5.3.1 Example Layouts.

(The Cardiac NM Option also requires support for MPR resampling and display, however this is documented separately in section 4.16.4.2.2.3.7).

4.16.4.2.2.3.6 General NM Option

Image Displays claiming the General NM Option shall support the display requirements indicated in the General NM Option column of table 4.16-1.

These requirements represent the basic display needs for general (i.e. non-cardiac) nuclear medicine.

4.16.4.2.2.3.7 Cardiac NM Option

Image Displays claiming the Cardiac NM Option shall support the display requirements indicated in the Cardiac NM Option column of table 4.16-1.

These requirements represent the basic display needs for cardiac nuclear medicine.

The Cardiac NM Option requires the ability to perform multiplanar reconstruction (MPR) of two re-oriented (short axis) cardiac RECON TOMO data sets to display the data in the standard format endorsed by the American College of Cardiology (ACC NM Cardiac Display). The ability to display more than two short axis data sets at the same time in the ACC Cardiac Display format is occasionally useful, but not required.

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4.18.4.1.2.3 Storage of Cardiac Images (NM)

Evidence Creators, Acquisition Modalities or Image Displays creating reconstructed tomographic datasets shall incorporate Image Orientation [Patient] (0020,0037) (inside the Detector Information Sequence (0054,0022)), Image Position (0020,0032), and Spacing Between Slices (0018,0088).

The standard cardiac views for reoriented RECON TOMO data are listed in Table 4.8-2.1. ~~In addition,~~ Evidence Creators creating a reconstructed tomographic dataset representing these standard cardiac views ~~(e.g. Short Axis)~~ shall include the View Code Sequence (0054,0220), ~~Slice Progression Direction (0054,0500),~~ and Acquisition Context Sequence (0040,0555) attributes~~, as appropriate~~. Slice Progression Direction (0054,0500) shall be included for short axis images. These values are used for determination of later display and formatting in the ACC NM Cardiac Display. These requirements and the possible values for these DICOM fields are more completely explained section 4.8.4.1.2.2 Storage of NM Images (NM), Table 4.8-2 and associated notes following the table.

If preferred window level settings based on activity within myocardial contours are known at the time of creation of cardiac short axis images, the information may be stored in Window Width (0028,1051) and Window Center (0028,1050). It is likely that use of presentation states will become the preferred method for storing this information in a future revision of the profile.

4.18.4.1.2.4 Result Screen Export Option

Evidence Creators claiming support of the Result Screen Export Option shall be capable of storing Result Screens as described in this section.

Result Screens refer to a presentation of result elements on the display, potentially including graphics, images and text, typically found on clinical analysis software such as NM cardiac packages.

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End of changes