Digital Imaging and Communications in Medicine (DICOM)

Supplement 45: Ultrasound Staged Protocol Data Management

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Introduction - will not appear in final standard

I.1 SCOPE AND FIELD OF APPLICATION

The purpose of this annex is to enhance consistency and interoperability among creators and consumers of Ultrasound images within Staged Protocol Exams. An ultrasound “Staged Protocol Exam” is an exam that acquires a set of images under specified conditions during intervals called “Stages”. An example of such an exam is a cardiac stress-echo Staged Protocol.

This informative annex does not create any new SOP Classes or change any existing IODs by adding attributes or changing attribute types. Instead, it specifies the means for conveying ultrasound Staged Protocol information through the consistent use of existing attributes within the following DICOM Services: Ultrasound Image and Ultrasound Multi-frame Image Storage, Modality Worklist, Modality Performed Procedure Step, and Key Object Selection Services.

An Ultrasound Staged Protocol Data Management Annex is added to Part 4

CHANGES TO NEMA STANDARDS PUBLICATION PS 3.4-2001

Digital Imaging and Communications in Medicine (DICOM)

64 # Part 4: Service Class Specifications

Item #1: Add Ultrasound Staged Protocol Data Management Annex

ANNEX X: ULTRASOUND STAGED PROTOCOL DATA MANAGEMENT (INFORMATIVE)

X.1 PURPOSE OF THIS ANNEX

The purpose of this annex is to enhance consistency and interoperability among creators and consumers of Ultrasound images within Staged Protocol Exams. An ultrasound "Staged Protocol Exam" is an exam that acquires a set of images under specified conditions during time intervals called "Stages". An example of such an exam is a cardiac stress-echo Staged Protocol.

This informative annex describes the use of ultrasound Staged Protocol attributes within the following DICOM Services: Ultrasound Image, Ultrasound Multi-frame Image, and Key Object Selection Storage, Modality Worklist, and Modality Performed Procedure Step Services.

X.2 PREREQUISITES FOR SUPPORT

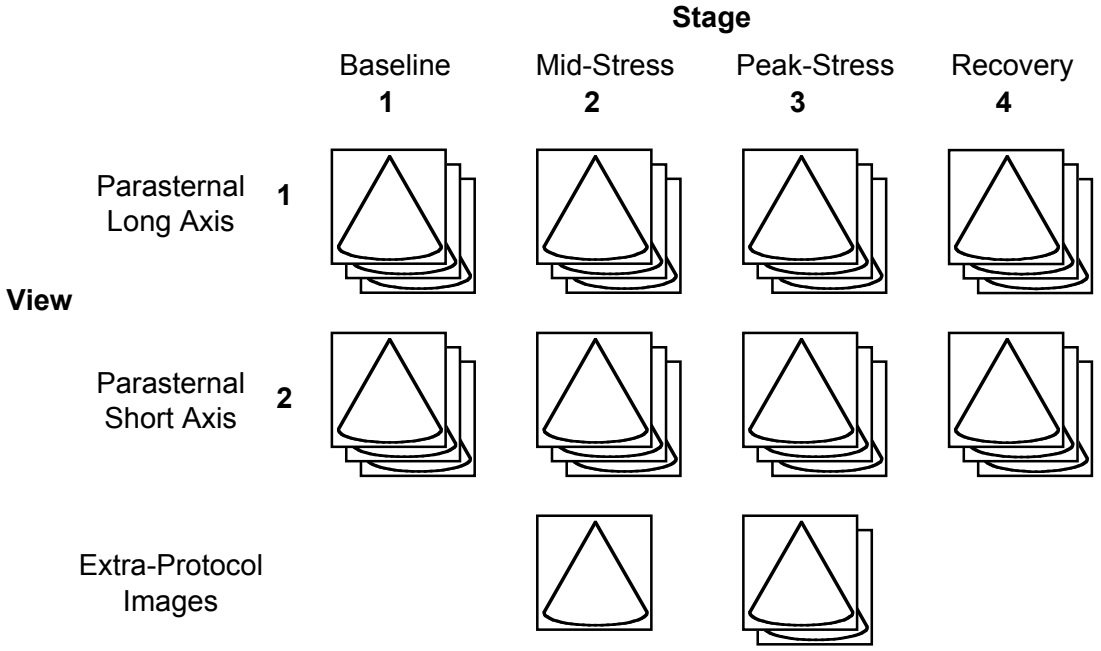
The support of ultrasound Staged Protocol Data Management requires support for the Ultrasound Image SOP Class or Ultrasound Multi-frame Image SOP Class as appropriate for the nature of the Protocol. By supporting some optional Elements of these SOP Classes, Staged-Protocols can be managed. Support of Key Object Selection allows control of the order of View and Stage presentation. Support of Modality Worklist Management and Modality Performed Procedure Step allow control over specific workflow use cases as described in this Annex. .

X.3 DEFINITION OF A STAGED PROTOCOL EXAM

A "Staged Protocol Exam" acquires images in two or more distinct time intervals called "Stages" with a consistent set of images called "Views" acquired during each Stage of the exam. A View is of a particular cross section of the anatomy acquired with a specific ultrasound transducer position and orientation. During the acquisition of a Staged Protocol Exam, the modality may also acquire non-Protocol images at one or more Protocol Stages.

A common real-world example of an ultrasound Staged Protocol exam is a cardiac stress-echo ultrasound exam. Images are acquired in distinct time intervals (Stages) of different levels of stress and Views as shown in Figure X.3-1. Typically, stress is induced by means of patient exercise or medication. Typical Stages for such an exam are baseline, mid-stress, peak-stress, and recovery. During the baseline Stage the patient is at rest, prior to inducing stress through medication or exercise. At mid-stress Stage the heart is under a moderate level of stress. During peak-stress Stage the patient's heart experiences maximum stress appropriate for the patient's condition. Finally, during the recovery Stage, the heart recovers because the source of stress is absent.

At each Stage an equivalent set of Views is acquired. Examples of typical Views are parasternal long axis and parasternal short axis. Examination of wall motion between the corresponding Views of different Stages may reveal ischemia of one or more regions ("segments") of the myocardium. Figure X.3-1 illustrates the typical results of a cardiac stress-echo ultrasound exam.



104 **Figure X.3-1**
CARDIAC STRESS-ECHO STAGED PROTOCOL US EXAM

X.4 ATTRIBUTES USED IN STAGED PROTOCOL EXAMS

The DICOM standard includes a number of attributes of significance to Staged Protocol Exams. This
108 Annex explains how scheduling and acquisition systems may use these attributes to convey Staged Protocol related information.

Table X.4-1 lists all the attributes relevant to convey Staged Protocol related information. (see PS 3.3 for details about these attributes).

112 **Table X.4-1**
ATTRIBUTES THAT CONVEY STAGED PROTOCOL RELATED INFORMATION

MODALITY WORKLIST (TAG) [RETURN KEY TYPE]	US IMAGE AND US MULTI-FRAME IOD (TAG) [TYPE]	MPPS IOD (TAG) [SCU/SCP TYPE]
----	----	Scheduled Step Attributes Sequence (0040,0270) [1/1] (b)
Study Instance UID (0020,000D) [1]	Study Instance UID (0020,000D) [1]	>Study Instance UID (0020,000D) [1/1]
----	Request Attributes Sequence (0040,0275) [3] (a,b)	----
Scheduled Procedure Step Sequence (0040,0100) >Scheduled Procedure Step Description (0040,0007) [1C]	>Scheduled Procedure Step Description (0040,0007) [3]	>Scheduled Procedure Step Description (0040,0007) [2/2]
Scheduled Procedure Step Sequence (0040,0100) >Scheduled Protocol Code Sequence (0040,0008) [1C]	>Scheduled Protocol Code Sequence (0040,0008) [3]	>Scheduled Protocol Code Sequence (0040,0008) [2/2]

----	Performed Procedure Step Description (0040,0254) [3]	Performed Procedure Step Description (0040,0254) [2/2]
----	Protocol Name (0018,1030) [3]	Performed Series Sequence (0040,0340) >Protocol Name (0018,1030) [1/1]
----	Performed Protocol Code Sequence (0040,0260) [3]	Performed Protocol Code Sequence (0040,0260) [1/1]
----	Number of Stages (0008,2124) [2C]	----
----	Number of Views In Stage (0008,212A) [2C]	----
----	Stage Name (0008,2120) [3]	----
----	Stage Number (0008,2122) [3]	----
----	Stage Code Sequence (0040,000A) [3]	----
----	View Name (0008,2127) [3]	----
----	View Number (0008,2128) [3]	----
----	Number of Event Timers (0008,2129) [3]	----
----	Event Elapsed Time(s) (0008,2130) [3]	----
----	Event Timer Name(s) (0008,2132) [3]	----
----	Transducer Position Sequence (0008,2240) [3]	----
----	> Transducer Position Modifier Sequence (0008,2242) [3]	----
----	Transducer Orientation Sequence (0008,2244) [3]	----
----	> Transducer Orientation Modifier Sequence (0008,2246) [3]	----

(a) Recommended if the Modality conforms as a SCU to the Modality Worklist SOP Class and Modality Performed Procedure Step

(b) Sequence may have one or more Items

X.5 GUIDELINES

This annex provides guidelines for implementation of the following aspects of Staged Protocol exams:

1. Identification of a Staged Protocol exam
2. Identification of Stages and Views within a Staged Protocol exam
3. Identification of extra-Protocol images within a Staged Protocol exam
4. Acquisition of multiple images of a View during a Stage, and identification of the preferred image for that Stage
5. Workflow management of Staged Protocol images

X.5.1 STAGED PROTOCOL EXAM IDENTIFICATION

The attributes Number of Stages (0008,2124) and Number of Views in Stage (0008,212A) are each Type 2C with the condition "Required if this image was acquired in a Staged Protocol." These two attributes will be present with values in image SOP Instances if the exam meets the definition of a Staged Protocol Exam stated in Section X.3. This includes both the Protocol View images as well as any extra-Protocol images acquired during the Protocol Stages.

The attributes Protocol Name (0018,1030) and Performed Protocol Code Sequence (0040,0260) identify the Protocol of a Staged Protocol Exam, but the mere presence of one or both of these attributes does not in itself identify the acquisition as a Staged Protocol Exam. If both Protocol Name and Performed Protocol Code Sequence attributes are present, the Protocol Name value takes precedence over the Performed Protocol Code Sequence Code Meaning value as a display label for the Protocol, since the Protocol Name would convey the institutional preference better than the standardized code meaning.

X.5.2 STAGE AND VIEW IDENTIFICATION

Display devices usually include capabilities that aid in the organization and presentation of images acquired as part of the Staged Protocol. These capabilities allow a clinician to display images of a given View acquired during different Stages of the Protocol side by side for comparison. A View is a particular combination of the transducer position and orientation at the time of image acquisition. Images are acquired at the same View in different Protocol Stages for the purpose of comparison. For these features to work properly, the display device must be able to determine the Stage and View of each image in an unambiguous fashion.

There are three possible mechanisms for conveying Stage and View identification in the image SOP Instances:

- "Numbers" (Stage Number (0008,2122) and View Number (0008,2128)) which number Stages and Views, starting with one.
- "Names" (Stage Name (0008,2120) and View Name (0008,2127)) which specify textual names for each Stage and View, respectively.
- One or more "code sequences" (Stage Code Sequence (0040,000A) for Stage identification, and Transducer Position Code Sequence (0008,2240) and Transducer Orientation Code Sequence (0008,2244) for View identification) which give identification "codes" to the Stage and View respectively.

View Number (0008,2128) and View Name (0008,2127) enable correlating the Views amongst the different Stages. The value set for Stage Name (0008,2120) and View Name are undefined. Therefore, this Annex recommends that the creator always send Stage Number (0008,2122) and View Number (0008,2128) to identify the Stage and View. Stages and Views are numbered sequentially and suggest a display sequence. There is a one-to-one correspondence between the number and the name for the images in the staged protocol. Names or code sequences allow the display device to label Stages and Views for the clinical user.

Table X.5-1 provides an example of the Staged Protocol relevant attributes in images acquired during a typical cardiac stress-echo ultrasound exam.

Table X.5-1
STAGED PROTOCOL IMAGE ATTRIBUTES EXAMPLE

BASELINE STAGE – VIEW 1	MID-STRESS STAGE – VIEW 1	MID-STRESS STAGE – VIEW 2
Study Instance UID : "1.2.840….123.1"	Study Instance UID : "1.2.840….123.1"	Study Instance UID : "1.2.840….123.1"
Request Attributes Sequence:	Request Attributes Sequence:	Request Attributes Sequence:

>Scheduled Procedure Step Description : ”Exercise stress echocardiography”	>Scheduled Procedure Step Description : ”Exercise stress echocardiography”	>Scheduled Procedure Step Description : ”Exercise stress echocardiography”
>Scheduled Protocol Code Sequence:	>Scheduled Protocol Code Sequence:	>Scheduled Protocol Code Sequence:
>>Code Value: ”P5-B3050”	>>Code Value: ”P5-B3050”	>>Code Value: ”P5-B3050”
>>Coding Scheme Designator: “SNM3”	>>Coding Scheme Designator: “SNM3”	>>Coding Scheme Designator: “SNM3”
>>Code Meaning: “Exercise stress echocardiography”	>>Code Meaning: ”Exercise stress echocardiography”	>>Code Meaning: ”Exercise stress echocardiography”
Performed Procedure Step Description: “Exercise stress echocardiography”	Performed Procedure Step Description: “Exercise stress echocardiography”	Performed Procedure Step Description: “Exercise stress echocardiography”
Protocol Name: “EXERCISE STRESS-ECHO”	Protocol Name: “EXERCISE STRESS-ECHO”	Protocol Name: “EXERCISE STRESS-ECHO”
Performed Protocol Code Sequence:	Performed Protocol Code Sequence:	Performed Protocol Code Sequence:
>Code Value: ”P5-B3050”	>Code Value: ”P5-B3050”	>Code Value: ”P5-B3050”
>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”
>Code Meaning: ”Exercise stress echocardiography”	>Code Meaning: ”Exercise stress echocardiography”	>Code Meaning: ”Exercise stress echocardiography”
Number of Stages: “4”	Number of Stages: “4”	Number of Stages: “4”
Number of Views In Stage: “2”	Number of Views In Stage: “2”	Number of Views In Stage: “2”
Stage Name: “BASELINE”	Stage Name: “MID-STRESS”	Stage Name: “MID-STRESS”
Stage Number : “1”	Stage Number : “2”	Stage Number : “2”
Stage Code Sequence:	Stage Code Sequence:	Stage Code Sequence:
>Code Value: ”P5-01202”	>Code Value: ”P5-01203”	>Code Value: ”P5-01203”
>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”
>Code Meaning:” Pre -stress image acquisition”	>Code Meaning:” Mid-stress image acquisition”	>Code Meaning:” Mid-stress image acquisition”
View Name: “Para-sternal long axis”	View Name: “Para-sternal long axis”	View Name: “Para-sternal short axis”
View Number : “1”	View Number : “1”	View Number : “2”
----	Number of Event Timers: “1”	Number of Event Timers: “1”
----	Event Elapsed Time(s): “10000” (ms)	Event Elapsed Time(s): “25000” (ms)
----	Event Elapsed Timer Name(s): “Time Since Exercise Halted”	Event Elapsed Timer Name(s): “Time Since Exercise Halted”
Transducer Position Sequence:	Transducer Position Sequence:	Transducer Position Sequence:
>Code Value: “T-D3136”	>Code Value: “T-D3136”	>Code Value: “T-D3136”
>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”
>Code Meaning: “Parasternal”	>Code Meaning: “Parasternal”	>Code Meaning: “Parasternal”
Transducer Orientation Sequence:	Transducer Orientation Sequence:	Transducer Orientation Sequence:
>Code Value: “G-A185”	>Code Value: “G-A185”	>Code Value: “G-A186

>Coding Scheme Designator: "SNM3"	>Coding Scheme Designator: "SNM3"	>Coding Scheme Designator: "SNM3"
>Code Meaning: "Long axis"	>Code Meaning: "Long axis"	>Code Meaning: "Short axis"

X.5.3 EXTRA-PROTOCOL IMAGE IDENTIFICATION

168 At any Stage of a Staged Protocol exam, the operator may acquire images that are not part of the Protocol. These images are so-called "extra-Protocol images". Information regarding the performed Protocol is still included because such images are acquired in the same Procedure Step as the Protocol images. The Stage number and optionally other Stage identification attributes (Stage Name and/or Stage
172 Code Sequence) should still be conveyed in extra-Protocol images. However, the View number should be omitted to signify that the image is not one of the standard Views in the Protocol. Other View identifying information, such as name or code sequences, may indicate the image location.

Table X.5-2
176 **COMPARISON OF PROTOCOL AND EXTRA-PROTOCOL IMAGE ATTRIBUTES EXAMPLE**

MID-STRESS STAGE – VIEW 1 PROTOCOL IMAGE	MID-STRESS STAGE EXTRA-PROTOCOL IMAGE
Study Instance UID : "1.2.840….123.1"	Study Instance UID : "1.2.840….123.1"
Request Attributes Sequence:	Request Attributes Sequence:
>Scheduled Procedure Step Description : " Exercise stress echocardiography protocol"	>Scheduled Procedure Step Description : " Exercise stress echocardiography protocol"
>Scheduled Protocol Code Sequence:	>Scheduled Protocol Code Sequence:
>>Code Value: " P5-B3050"	>>Code Value: " P5-B3050"
>>Coding Scheme Designator: "SNM3"	>>Coding Scheme Designator: "SNM3"
>>Code Meaning:" Exercise stress echocardiography"	>>Code Meaning:" Exercise stress echocardiography"
Performed Procedure Step Description: "Exercise stress echocardiography"	Performed Procedure Step Description: "Exercise stress echocardiography"
Protocol Name: "EXERCISE STRESS-ECHO"	Protocol Name: "EXERCISE STRESS-ECHO"
Performed Protocol Code Sequence:	Performed Protocol Code Sequence:
>Code Value: "P5-B3050"	>Code Value: "P5-B3050"
>Coding Scheme Designator: "SNM3"	>Coding Scheme Designator: "SNM3"
>Code Meaning:" Exercise stress echocardiography"	>Code Meaning:" Exercise stress echocardiography"
Number of Stages: "4"	Number of Stages: "4"
Number of Views In Stage: "2"	Number of Views In Stage: "2"
Stage Name: "MID-STRESS"	Stage Name: "MID-STRESS"
Stage Number : "2"	Stage Number : "2"
Stage Code Sequence:	Stage Code Sequence:

>Code Value: ”P5-01203”	>Code Value: ”P5-01203”
>Coding Scheme Designator: “SNM3”	>Coding Scheme Designator: “SNM3”
>Code Meaning:” Mid-stress image acquisition”	>Code Meaning:” Mid-stress image acquisition”
View Name: “Para-sternal long axis”	----
View Number : “1”	----
Transducer Position Sequence:	----
>Code Value: “T-D3136”	----
>Coding Scheme Designator: “SNM3”	----
>Code Meaning: “Parasternal”	----
Transducer Orientation Sequence:	----
>Code Value: “G-A185”	----
>Coding Scheme Designator: “SNM3”	----
>Code Meaning: “Long axis”	----

X.5.4 MULTIPLE IMAGES OF A STAGE-VIEW

Ultrasound systems often acquire multiple images at a particular stage and view. If one image is difficult to interpret or does not fully portray the ventricle wall, the physician may choose to view an alternate. In some cases, the user may identify the preferred image. The Key Object Selection Document can identify the preferred image for any or all of the Stage-Views. This specific usage of the Key Object Selection Document has a Document Title of (113013, DCM, “Best In Set”) and Document Title Modifier of (113017, DCM, “Stage-View”).

X.5.5 WORKFLOW MANAGEMENT OF STAGED PROTOCOL IMAGES

X.5.5.1 UNINTERRUPTED EXAMS – SINGLE MPPS

Modality Performed Procedure Step (MPPS) is the basic organizational unit of Staged Protocol Exams. It is recommended that a single MPPS instance encompass the entire acquisition of an ultrasound Staged Protocol Exam if possible.

There are no semantics assigned to the use of Series within a Staged Protocol Exam other than the DICOM requirements as to the relationship between Series and Modality Performed Procedure Steps. In particular, all of the following scenarios are possible:

1. one Series for all images in the MPPS
2. separate Series for Protocol View images and extra-Protocol images in the MPPS
3. separate Series for images of each Stage within the MPPS
4. more than one Series for the images acquired in a single Protocol Stage.

There is no recommendation on the organization of images into Series because clinical events make such recommendations impractical. Figure X.5.5-1 shows a possible sequence of interactions for a protocol performed as a single MPPS.

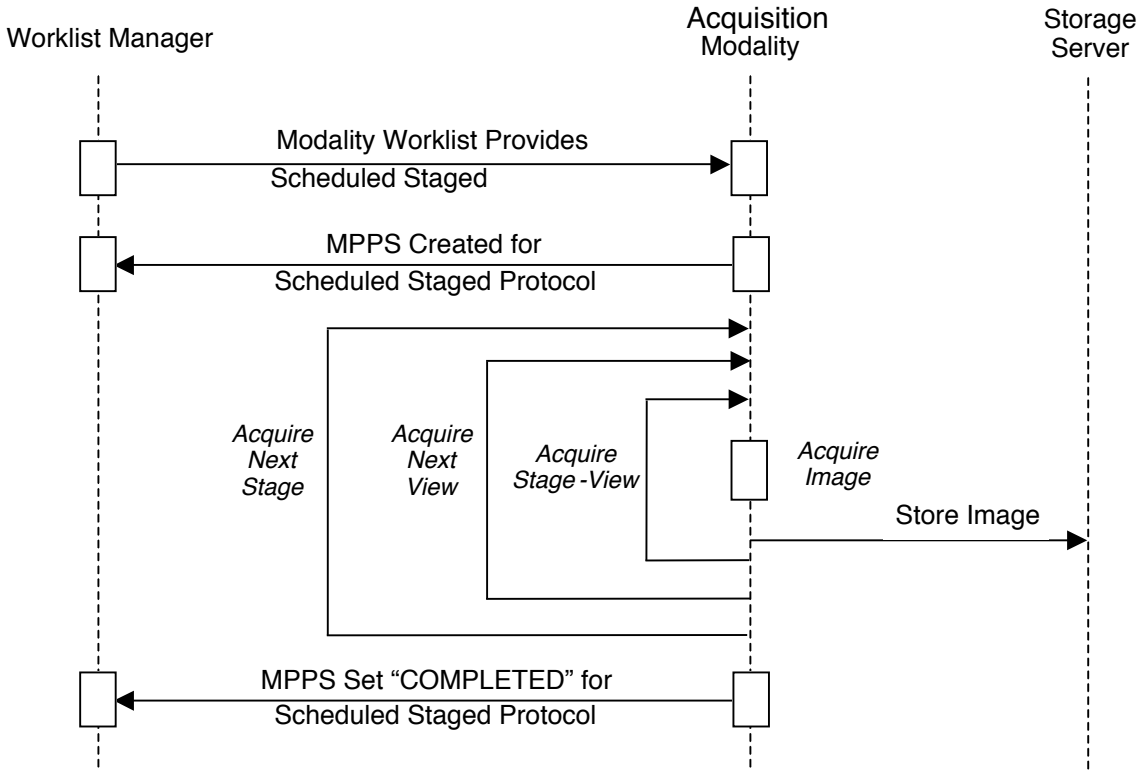


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FIGURE X.5.5-1 EXAMPLE OF UNINTERRUPTED STAGED-PROTOCOL EXAM WORKFLOW

X.5.5.2 INTERRUPTED EXAMS – MULTIPLE MPPS

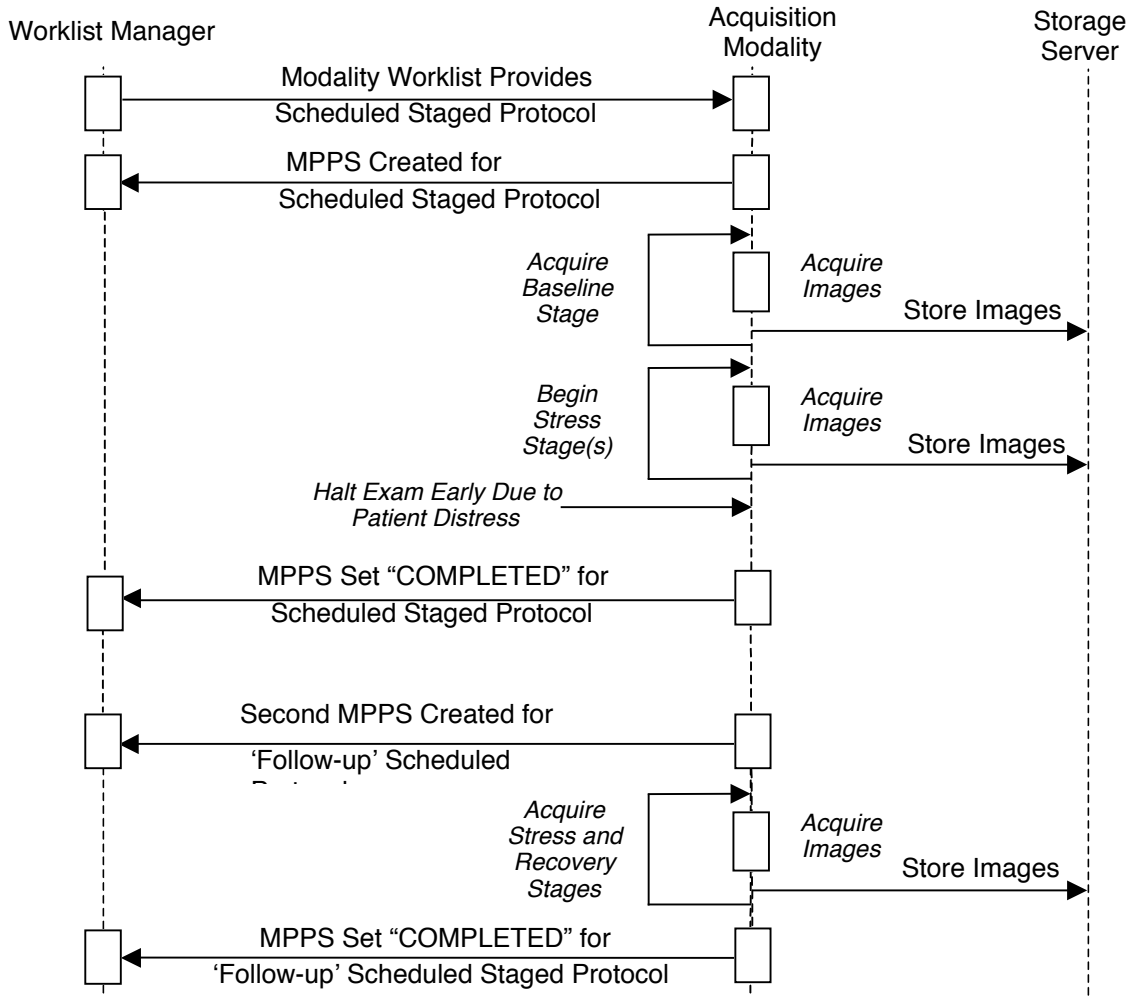
A special case arises when the acquisition during a Protocol Stage is halted for some reason. For
204 example, such a situation can occur if signs of patient distress are observed, such as angina in a cardiac stress exam. These criteria are part of the normal exam Protocol, and as long as the conditions defined for the Protocol are met the MPPS status is set to COMPLETED. Only if the exam terminates before meeting the minimum acquisition requirements of the selected Protocol would MPPS status be set to
208 DISCONTINUED. It is recommended that that the reason for discontinuation should be conveyed in the Modality Procedure Step Discontinuation Reason Code Sequence (0040,0281). Staged Protocols generally include criteria for ending the exam, such as when a target time duration is reached or if signs of patient distress are observed.

212 If a Protocol Stage is to be acquired at a later time with the intention of using an earlier completed Protocol Stage of a halted Staged Protocol then a new Scheduled Procedure Step may or may not be created for this additional acquistion. Workflow management recommendations vary depending on whether the care institution decides to create a new Scheculed Procedure Step or not.

216 Follow-up Stages must use View Numbers, Names, and Code Sequences identical to those in the prior Stages to enable automatically correlating images of the original and follow-up Stages.

X.5.5.2.1 UNSCHEDULED FOLLOW-UP STAGES

Follow-up Stages require a separate MPPS. Since follow-up stages are part of the same Requested
220 Procedure and Scheduled Procedure Step, all acquired image SOP Instances and generated MPPS instances specify the same Study Instance UID. If the Study Instance UID is different, systems will have difficulty associating related images. This creates a significant problem if Modality Worklist is not supported. Therefore systems should assign the same Study Instance UID for follow-up Stages even if
224 Modality Worklist is not supported. Figure X.5.5-2 shows a possible interaction sequence for this



scenario.

FIGURE X.5.5-2 EXAMPLE STAGED-PROTOCOL EXAM WITH UNSCHEDULED FOLLOW-UP
228 **STAGES**

X.5.5.2.2 SCHEDULED FOLLOW-UP STAGES

In some cases a new Scheduled Procedure Step is created to acquire follow-up Stages. For example, a
232 drug induced stress-echo exam may be scheduled because an earlier exercise induced stress-echo exam had to be halted due to patient discomfort. In such cases it would be redundant to reacquire earlier

Stages such as the rest Stage of a cardiac stress-echo ultrasound exam. One MPPS contains the Image instances of the original Stage and a separate MPSS contains the follow-up instances.

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If Scheduled and Performed Procedure Steps for Staged Protocol Exam data use the same Study Instance UID, workstations can associate images from the original and follow-up Stages. Figure X.5.5-3 shows a possible interaction sequence for this scenario.

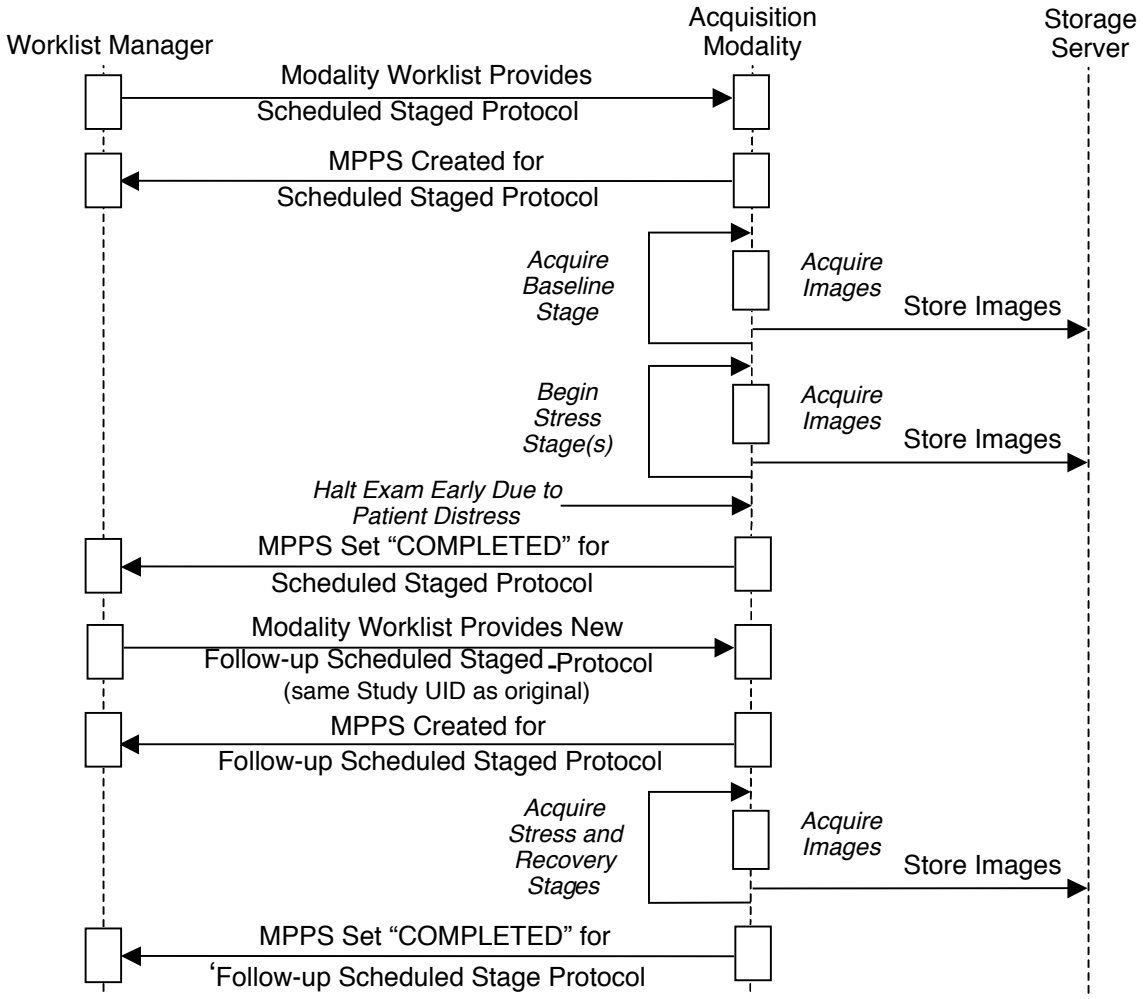

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FIGURE X.5.5-3 EXAMPLE STAGED-PROTOCOL EXAM WITH SCHEDULED FOLLOW-UP STAGES