Minimizing Digital Imaging and Communications in Medicine (DICOM) Modality Worklist Patient/Study Selection Errors

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Frequently when patient and study identification information (patient name, patient identification, date of birth, sex, and accession number) are manually entered at a modality, typographical errors occur that have to be corrected before the acquired images can be matched to the proper patient and study on a picture archiving and communication system (PACS). The Digital Imaging and Communication in Medicine (DICOM) Modality Worklist service alleviates these problems by automatically transferring this data from the radiology information system (RIS) to the image acquisition modality. The technologist then does not have to manually re-enter the data to place it into the image files. With modality worklist, precise patient and study data are obtained and placed into the image headers with no typographical errors. When the images are sent to the PACS, they match the corresponding patient and study records, and are immediately incorporated into the electronic patient record. While modality worklist does replace the manual keying of the data and virtually eliminates typographical problems, it introduces a new source of human error: the incorrect selection of the patient and/or study from the computerized worklist, and the resultant mislabeling of the images. When these mislabeled images are sent to the PACS, they are immediately associated with the wrong patient and/or study, where they potentially may cause serious harm. The goal of this report is to raise awareness to this problem, to identify the major causes of these errors, and to offer some practical suggestions on how to minimize them.

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OVER THE LAST DECADE, the Department of Veterans Affairs (VA) has been a leader in the adoption of digital imaging for medicine. The VA has gained considerable experience with digital modalities, both at sites using commercial picture archiving and communication systems (PACS) and others using the internally developed VistA system.¹⁻³ In 1998, the VA published a document requiring the modality worklist service for all new radiology modality purchases.⁴ Beginning in 1999, the Integrating the Healthcare Enterprise (IHE) demonstration project sponsored by the Radiological Society of North America (RSNA) and the Healthcare Information Management Systems Society (HIMSS) also included the modality worklist service.⁵ Now more than 100 different models of modalities are interfaced in the VA,

giving us experience with many different modality worklist implementations.

DICOM MODALITY WORKLIST

The Modality Worklist service was introduced into the 1996 Digital Imaging and Communications in Medicine (DICOM) standard to electronically transfer patient demographics and study information from the radiology information system (RIS) to the image acquisition modality.⁶

The protocol allows the modality to query the worklist provider (an intermediate system between the RIS and the modality) to obtain the patient and study information about currently scheduled examinations (that is, the Scheduled Procedure Steps). The RIS supplies the worklist provider with a stream of new orders, patient arrival events, and examination completion information. The worklist provider maintains a database of pending scheduled procedure steps, adding an entry to the database for each new order and deleting entries as examinations are completed. A new DICOM service, Modality Performed Procedure Step, was added in 1999 to allow the modality to notify the modality worklist provider when examinations are started and are completed.

The modality is allowed great flexibility in specifying the content and frequency of the query. The modality indicates what examination data are to be returned by specifying a series of DICOM elements (such as patient name, patient ID, accession number, procedure, and scheduled date and time). Some of the DICOM elements have values and serve as the keys for the query. The other DICOM elements are null and are to be filled in by the modality worklist provider. When the modality worklist provider receives a query, it uses the

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values in the elements as keys to select the patients and studies of interest from its database, and returns values for all the specified elements. Queries may be as broad (all studies) or as narrow (just one examination) as desired. They may be automatically generated at frequent intervals with periodic polling of the modality worklist provider or they may be generated only on demand when needed.

SCOPE OF PROBLEM

One study found that when the patient and study information is manually entered at the modality, the error rate is on the order of 5% (33 errors out of 634 cases).⁷ When the patient and study information is obtained automatically using the modality worklist, patient/study miss-selection errors occur instead of typographical errors. One study of modality worklist mismatches performed in the VA reported an error rate of 0.26% (126 mismatches out of 48,800 studies).⁸ Another VA study at a different facility reported a patient/study mismatch error rate of 0.73% (682 out of 93,300 studies), but this figure included all sources of error, not just those attributable to modality worklist mismatches.⁹ Note that in both instances the actual error rate may be slightly higher in reality, since undetected patient/study mismatches are not included in these statistics.

Compared with the previous typographical errors, which were far more numerous, the patient/study mismatch errors that occur now with modality worklist result in images that are incorrectly associated in the electronic patient record, which are much harder to detect, more difficult to correct, and can potentially cause patient harm.

On the VistA system, when data are manually entered incorrectly, the typographical error is detected *before* the images are associated with the corresponding patient and study and stored in the electronic patient record. An automatic procedure detects the error, aborts the association process, and flags the incorrect study's images. Manual intervention is then required to correct the typing error to allow the association process to proceed.

There is no automatic error detection when the images are mislabeled for the wrong patient and/or study. When a modality worklist miss-selection occurs, association proceeds unchecked as the images are matched with the wrong patient and study and are stored incorrectly in the electronic patient record. This kind of error can only be detected

afterwards, when these images are displayed for the wrong patient and/or study. Finding and correcting these errors is a much more difficult task, and it must be done quickly, as the images stored for the wrong patient may be available for general viewing. Procedures can be put in place to assist this process.

When a patient/study mislabel error is detected, it is important to determine the extent of the problem and exactly what happened. It is necessary to identify the right patient/study for the images, and correct the electronic patient record. It is necessary to review previous radiologist reports and to notify clinicians treating the patient(s) of the difficulty.

DIFFERENT MODALITY WORKLIST IMPLEMENTATIONS

The modality vendors have implemented several different scenarios:

- (1) The modality automatically generates a broad worklist query every 30 seconds to obtain an up-to-date list of all the pending requests. The technologist selects the patient/study from a picklist using the mouse, and double-clicks on the patient/study on the picklist to verify the selection and send the images to the PACS.
- (2) The modality generates a broad modality worklist query on demand to obtain an up-to-date list of the pending requests and display a numbered list of the pending patient/study examinations. The technologist enters the number of the corresponding patient/study to select it. The modality displays pertinent patient/study information and requires the technologist to verify the selection before sending the images to the PACS.
- (3) The technologist enters the unique accession number and performs a narrow modality worklist query. The modality displays pertinent patient/study information and requires the technologist to verify the selection before sending the images to the PACS.
- (4) The technologist scans the bar code on the patient wrist and automatically obtains data to perform a narrow modality query. The modality displays pertinent patient/study information and requires the technologist to verify the selection before sending the images to the PACS.

Some of these implementations are less error-prone than others.

SOURCES OF PATIENT/STUDY SELECTION ERRORS

When a worklist patient/study mismatch occurs, it almost always involves two different examinations that are being performed at about the same time.

Picklist Problem

A modality worklist patient/study selection error can occur when an adjacent entry on a picklist is inadvertently chosen. This most frequently occurs when the wrong patient and/or study is obtained from a picklist of scheduled procedure steps based on a broad query, and the selection is performed using a mouse. The modality workstation screen presentation size is also a factor—smaller font size with more entries increases the chance of making a mouse-pointing mistake because the entries are closer together.

Two different kinds of errors are possible. First, the wrong patient can be selected. The images will then automatically be posted to the wrong patient and the wrong study. This error should be picked up by the technologist performing quality assurance on the study, or by a radiologist, and corrected within the department. Otherwise, the error might be discovered in the wards, when a clinician might notice the discrepancy (that is, the patient now appears to have pneumonia and a pacemaker, when this morning he/she did not have either). It is also possible that this kind of error might not be detected immediately, for example, if there were no previous studies, and not be detected until a later time, perhaps when other studies are performed.

The second kind of error occurs when the wrong study is selected for the patient. This typically happens when a patient has two studies ordered for the same modality at the same time, for example a Chest AP and Lateral along with a leg x-ray. If these get reversed, or both examinations are associated with only one of the studies (a common experience in the VA), an error occurs.

Insufficient Data Problem

Experience using modality worklist has shown that at least five different patient/study data items must be presented on a picklist to properly identify

scheduled procedure steps: patient name, patient identifier, study accession number, requested procedure, and procedure date.⁸

At present, some modality worklist implementations present only a subset of this information, resulting in a picklist that is occasionally ambiguous. Without clear data, the technologist may be forced into making an educated guess.

SUGGESTIONS FOR PREVENTING PATIENT/STUDY SELECTION ERRORS

The responsibility for minimizing patient/study selection errors extends beyond the technologist who is responsible for performing the examination. While modality worklist has to be “quick, easy, and require the least number of steps,” the selection process has to be engineered to minimize the chance of human mistake. Time spent on ensuring accuracy in the patient/study selection process at the modality reduces the amount of corrective effort required later and possible errors in patient care.

Some of the suggestions below can be implemented easily, either as a configuration change on the modality or as a change in procedure. Others may require new vendor software.

Patient/Study Selection Verification Step

The modality should require the technologist to verify that the correct patient and study have been selected before placing that information into the image headers and sending them to the PACS. This is a published VA requirement for all new modalities.⁴

Minimize Number of Choices

The smaller the number of patients and studies that are presented to the technologist, the smaller will be the error in selecting the correct one. Too many entries will clutter up the list. The goal is to return the minimum number of scheduled procedure steps in a query. Properly configuring the modality worklist query parameters can reduce the number of items in a broad query.

For example, only those patients who are physically waiting to be examined at the modality should be presented on the worklist. In the IHE model, the RIS is supposed to notify the modality worklist provider of the patient arrival event, which should change the status of the corresponding scheduled procedure step(s) from “SCHED-

ULED" to "ARRIVED."⁵ These scheduled procedure step(s) remain in the modality workload provider database until they are completed. The modality can be configured to send the value "arrived" in the Scheduled Procedure Step Status (0040,0020) of the query, then only the "arrived" scheduled procedure steps should be returned and appear on the workload for selection.

Configuring the modality to specify a small scheduled procedure step date and time window can also help.

Query by Patient ID Accession Number

Broad workload queries should be performed only occasionally, for determining the size of the workload or determining if a particular patient is scheduled. Narrow workload queries by patient or accession number are much more accurate for selecting the right patient and study.

When the technologist enters the patient identifier or the accession number at the modality, a narrow query is performed, and the corresponding patient and study (or studies) are displayed. The technologist would then select the appropriate study (if there were more than one), verify the correct patient and study, and proceed with the examination.

The accession number query capability is required by both the VA and the IHE, and should now be available at every new modality.^{4,5}

Missing Study on the Modality Workload

The technologist performing the examination should be the first line of defense in detecting mislabeled images. A technologist can sometimes detect a mislabeled patient/study before doing the examination. If an examination that is about to be performed "mysteriously disappears" from the modality workload, it might be because it was inadvertently used for someone else's images.

Examination Verification

On completion of the examination, and after the images have been transmitted to the PACS, the technologist must view the images on the PACS to determine that they have been properly stored. The technologist should *always* perform this image verification step at the conclusion of the examination in order to detect mislabeled images. (This cannot be emphasized enough!) The workstation used for the verification process should be located

near the modality acquisition workstation, so that the images on the two can be compared.

In order for the images to be visible on the PACS, several conditions must be successfully satisfied:

- (1) The image headers must have the correct patient and study information.
- (2) The images must be successfully transmitted from the modality to the PACS.
- (3) There should be no additional images (from another study) and no missing images.
- (4) The images must be properly associated with the corresponding patient and study in the electronic medical record.
- (5) The images must be correctly stored in the archive.
- (6) The images must be properly displayed on the PACS workstation and be the same images as on the modality acquisition workstation.
- (7) The images should be of diagnostic quality.

As errors can occur in any of these steps, examination verification a very important quality-assurance procedure. Images should not be permitted to be viewed elsewhere until this step is performed. If a problem is encountered, there are many steps that the technologist can take at this point to determine the extent of the difficulty.

Mistakes in procedure selection (that is, right patient, wrong study) are also easily detected by this procedure.

Display Enough Data

The modality vendors need to provide a way to display the full set of data required.

Electronic Patient Identification

Data from a bar code on a patient's wristband can positively identify the patient and be used to generate a narrow modality workload query. This essentially automates the patient selection process and removes the technologist as a source of human error.

CONCLUSIONS

DICOM modality workload is an excellent mechanism for transmitting patient and study information from the RIS to the image acquisition modality. Attention needs to be paid to the patient/study selection process, however, to minimize the chance of

error. While errors occur infrequently, they are time-consuming to correct, and can put patients at risk.

Errors in patient/study selection process can be reduced by making procedural changes in the use of modality worklist, such as using narrow queries instead of broad ones. They can also be lessened by using better human engineering at the workstation, and will be further reduced by using electronic

patient identification and eliminating the manual patient selection step entirely.

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