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Experience with Importation of Electronic Images into the Medical Record from Physical Media

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Abstract The purpose of this article is to describe a system we developed for importing images on compact discs (CDs) from external imaging departments into our clinical image viewing system, and to report on key metrics regarding veracity of information seen on the CDs. We recommend careful attention to the process of CD importation because of the error rate we have seen. We developed a system and process for importing images on CD into our EMR. The importation system scans the CD for digital imaging and communications in medicine (DICOM) images, and collects all patient information seen. That information is presented to the patient for verification. Once validated, the image data is copied into our clinical viewing system. The importation system includes facilities for collecting instances of incorrect data. About 90% of images are now exchanged between our healthcare enterprise and other entities via CD. Data for the wrong patient (e.g., the wrong CD) is seen in about 0.1% of cases, and a similar number of CDs have data for more than one patient on the CD(s) the patient bring to our facility. Most data are now exchanged via DICOM files. DICOM images burned onto CD media are now commonly used for image exchange. However, applications to import DICOM images are not enough. One must implement a process to assure high confidence that the data imported belongs to the patient you are importing.

Keywords Digital imaging and communications in medicine (DICOM) · Electronic medical record (EMR) · Image distribution · Integrating healthcare enterprise (IHE) · Medical record linkage · Teleradiology · Workflow re-engineering

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Background

The transition from film imaging to digital imaging has been a great advance for most radiology departments and hospitals [1, 2]. One of the important remaining challenges is the exchange of images between hospitals [3]. In most cases, images are transferred between facilities using compact discs (CDs), with the images usually stored as digital imaging and communications in medicine (DICOM) files and many of these also implementing a DICOMDIR per the DICOM part 10 specification [4]. While it is relatively simple to produce CDs with images, the anecdotal reports of most imaging departments are that it is a much greater challenge to use the images received on CDs. The purpose of this study was to document current trends in image exchange, including measuring the fraction of examinations exchanged via electronic media versus film, and to measure the rate and nature of errors present on the CDs that were received.

Methods

We developed an application that could read CDs, identify DICOM images as well as other files on the CDs, and transmit the DICOM images to our electronic medical record viewer. The application also records information, including the number of patients, the number of studies, the number of images, and the size of the imaging studies present on each CD as a part of its output.

The computer application we developed (Fig. 1) scans the CD for all DICOM image data and extracts the patient name, date of birth, medical record number, and the dates/names of examinations and present those on the computer display. The application was written in C++ and utilizes the Oldenburg DICOM toolkit known as DCMTK (http://dicom.offis.de/dcmtk.php.en). If there is more than one patient name or date of birth, they are listed on the display. In most cases, this step is done when the patient arrives at the first clinical desk at the start of an episode of care. The patient is then asked to confirm that any or all forms of their name, and that the exams listed do belong to them. All patient demographics information in the DICOM header of "accepted" examinations was replaced with information from our registration system as the images are imported into our clinical image display system. We also replace the medical record number. This assures that the viewer will display the same information regardless of whether it uses information from the DICOM header or from the electronic medical record (EMR). This is an internally developed application[5] that provides flexibility to include these images, but we color code them in the list (red) to make it easy for clinicians to identify. We also copy the original unaltered data to a separate store in case of any question about patient identity.

The initial application cleared the accession number and did not fill in any value to assure that there would not be any conflict with local systems. There was no connection with a system that could provide a guaranteed unique accession number, and so this field was left empty. We are now building an interface to the RIS to allow the connection of a report with these outside examinations, and at that time, a valid accession number will be placed in the DICOM header.

This application was implemented into our practice about 5 years ago, and so the data presented here about information on CDs reflect this 5-year history. In addition, our institution has had a decade-long policy of tracking outside films that were carried by patients to our facility; that same process was implemented for tracking CDs (including ones that are not imported into the record). The combination of these two data sources was used to collect information on film and electronic image examinations being sent into our institution.

The application was initially deployed in the radiology records area, but rapidly distributed to most clinical desks. Only areas that rarely import CDs (e.g., obstetrics) do not have this application—such areas send the CDs to the radiology desk for importation. Over 90% of CD images are imported by clinical desks outside radiology. This review of the data was collected after the institutional review board granted an exemption.

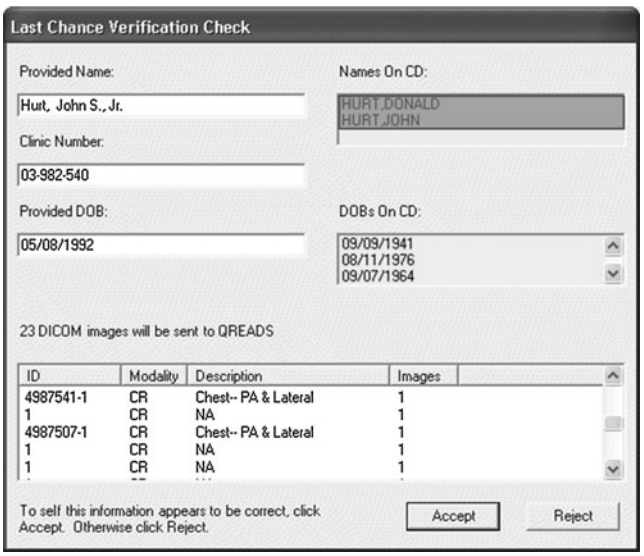

Fig. 1 Screen capture of the CD image import application. The *left side* shows patient info from the Enterprise Registration System based on the medical record number typed in by the desk attendant, while the *right side* shows names/DOBs found on the CD. The application shows two names found on the CD, and three different birthdates. These are highlighted to be more noticeable in the application. Reconciliation then involves the patient identifying which studies do belong to them (e.g., "that was my maiden name" or "that was my birthday—I am sure I did not have a barium enema on that day"

Results

Figure 2 shows the number of film examinations as well as the number of digital examinations that were received on CD and transferred into the image distribution system since the beginning of this project; it documents a steady increase

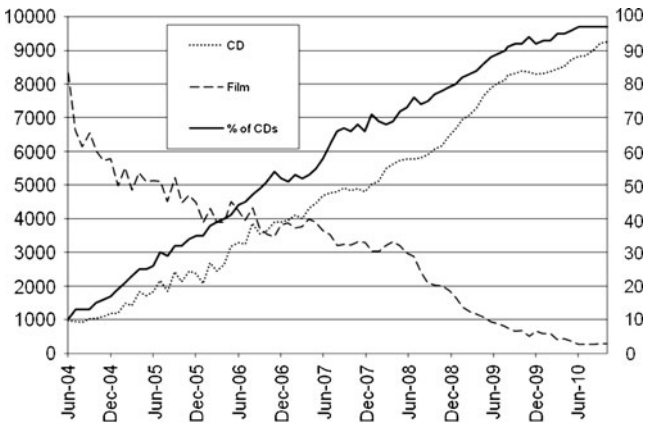

Fig. 2 Volume of CDs and traditional film received by our institution since June 2004. The scale shown on the *left* is the number of exams received per month (CD in *solid black line* and film is *dotted line*). The *right-hand scale* shows this expressed as percentage of exams that were received on CD

in the number of examinations arriving on CDs. Our institution is now approaching 90% of examinations being transferred via CD rather than by film media. We suspect that the usage of CDs is not specific for an importing institution, and so this probably is an accurate reflection of CD use in the United States.

As noted, the image importation application collects information on data integrity, and it shows that the correct patient but with different forms of the name or identifier on the same CD is seen in 1.2% of cases. This includes changes due to marriage, divorce, or adoption. We also note that 0.6% of CDs are unreadable after multiple attempts on multiple computers.

Data for the *wrong* patient is seen on 0.1% of CDs and data for more than one person is seen on an additional 0.1% of CDs. We emphasize that we know this is the wrong patient because our import process has the patient standing next to the person doing the CD import, confirming the error. These error rates have not changed substantially over the 5-year period.

Finally, as noted above, the application scans the CD for all types of files and records the file extension. We find that non-DICOM files (most frequently JPEG format images) constitute about 4% of all files seen on the CD and it has remained fairly steady over the past 3 years, falling from 7% to 10% during the first 2 years. In many cases, these are duplicates of the DICOM images, though we have not visually reviewed this to measure the actual rate.

Discussion

The exchange of images is a medical necessity, but there are significant challenges in utilizing images received on CDs from other institutions. We believe the most important challenge is that errors in the information on the CD may not be as readily apparent as on film—certainly they are less visible until the CD is "read" in a computer. While most picture archiving and communication systems (PACS) have the capability to import DICOM images, the true emphasis must be on the process by which this occurs. By involving the patient early (at the desk when there may be less stress) with a desk support person, we believe represents the highest likelihood of accurate confirmation. We are aware of one case in the past 5 years when an exam was imported using this process but which subsequently proved to be incorrect. In some situations (e.g., emergency transfers) requiring the patient to confirm may not be possible, but family members or transfer personnel can be a good surrogate. We recognize that this is not a perfect process, but likely addresses most of the problems.

The total significant error rate is 0.2–0.1% being the wrong patient only, and 0.1% having both the right patient and another patient's data on the CD. While the error rate is seemingly low at 0.1% for wrong patient and also 0.1% for more than one patient, this is actually a significant problem. At the volume of exams we import, the rate of 0.1% CDs with the wrong patient means approximately one CD per day is for the wrong patient. It is infrequent enough that desk personnel who are expected to do many tasks can easily fail to detect the problem, but common enough that this cannot be ignored. We believe this is a critical problem that hospitals must carefully consider when implementing their processes and systems.

The inclusion of information for more than one patient is also a problem, but is a problem for the source hospital because it likely represents a Health Insurance Portability and Accountability Act (HIPAA) violation. The consequences of such a violation have recently become more severe with the passage of the Patient Safety and Quality Improvement Act [6]. For this reason, hospitals should carefully study their process and software for creating CDs and take steps to avoid this risk.

Given the volume of examinations handled and the error rate, the most important consideration in dealing with images received on CD is to identify a workflow that assures high integrity of the information while not reducing clinical efficiency. The integrating healthcare enterprise (IHE) framework [3, 7] does identify a workflow for importing CD images—the import reconciliation work flow or IRWF—that leverages the scheduled workflow profile. The primary actor for this is the portable media importer; it creates an order so that the downstream systems can have a "handle" for dealing with the images. This allows the importation of evidence objects (which in this case is images but other information can be imported from the CD as well as other media or even the Internet). An enterprise identifier is often placed into the imported object(s) so that enterprise systems can accurately connect these objects to the patient. We note here that the import reconciliation workflow has both a scheduled and unscheduled form and these two forms are detailed in Figs. 3a, b, which are adapted from the IHE website.

While the IRWF is necessary, it is not sufficient for a clinical practice because it does not describe a clinical implementation or provide details on how a hospital may assure data integrity. These need for high data integrity can conflict with the need for clinical efficiency—developing a process and system to achieve these goals is critical.

The particular clinical setting will have a major impact on the most efficient implementation of image importation. In the case of a large group practice or hospital, we would recommend that all examinations on all CDs should be imported. We recognize that in many cases, some images

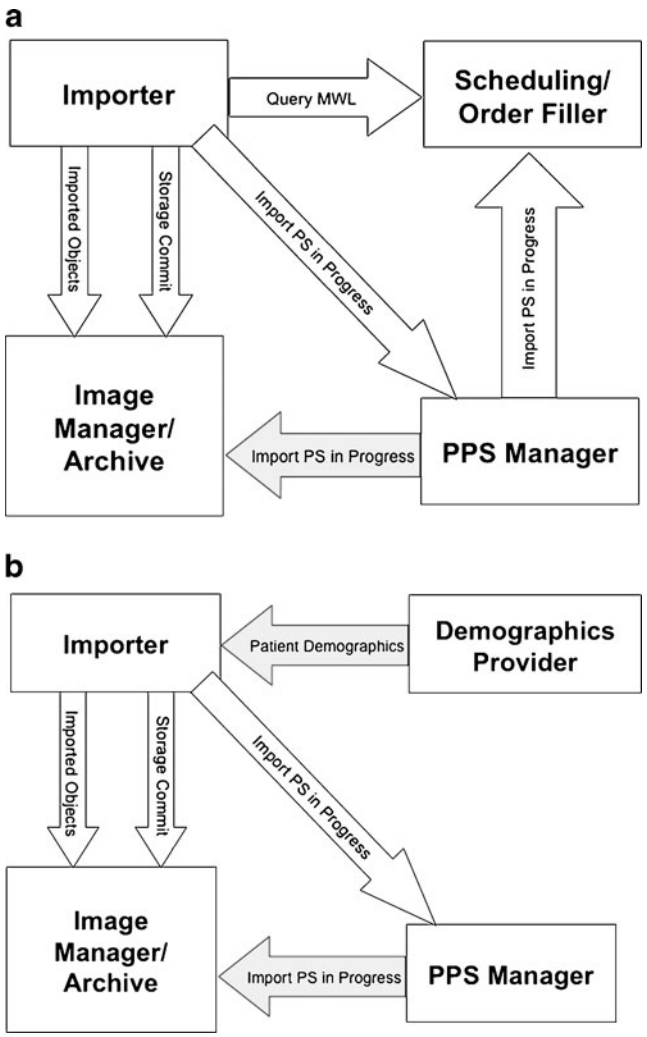

Fig. 3 IHE-defined IRWF profile for importation of images from media such as CD. **a** Shows scheduled IRWF for cases where an order is provided prior to the import of the images. **b** Shows unscheduled IRWF for cases where no order exists. Adapted from http://IHE.net

on the CD will not be relevant to the care of the patient. The challenge is to predict which images will not be relevant. This is a challenge, particularly since the exam descriptions on the CD are not always obvious. Because of these challenges, it is often most efficient to simply import every valid examination on the CD. In the case of an imaging center or small imaging facility, it may be more sensible have a person decide. The right person may be a desk attendant, technologist, or even the radiologist.

The issue of image access is also critical. In the setting of a hospital or large group practice, it may be impractical to have the CD carried with the patient because teams often work in parallel and away from the patient. The result would be contention for the access to the CD. In addition, this can allow the CD to become lost. In a large practice situation, the best solution is to import the images into the EMR or PACS to allow widespread access. This has the additional advantage of letting the physicians use a graphical user interface that they are already familiar with and it also would likely be easier to compare the outside study with internal studies. In the case of an imaging center, the small physical size of the facility makes it more feasible to not import the CD and instead use either a viewer on the CD or a viewer on a local workstation without a formal import process. We simply note here that it may be more efficient to compare exams if the CD is imported, and one can allow the patient to leave the facility with the CD before the images are interpreted. If a facility *does* keep the CD, it must be responsible for storing or destroying it in a secure fashion.

Another important consideration for workflow is the naming of the procedures. There is as yet, no universal standard for how to describe imaging procedures in radiology. As a result, the study description in the DICOM header is variable and it may not be easy for all physicians, particularly non-radiologists, to know what study was done. We have found that a simple string lookup and mapping can provide a correct match in approximately 80% of the cases that we have seen. However, a significant fraction of the remaining 20% is much more difficult to determine. For these, it is probably necessary to use the description unmodified.

Given the frequency at which errant CDs are seen, we believe that that is a good argument for having a high-quality import process. We should note that if the "distribute the CD" approach is taken, it means that even though one team might identify a problem with the CD, other teams may not be aware that incorrect data is present on the CD, and the problem could be propagated.

At the time the image CD importation application was implemented, we decided to not import non-DICOM data because the other image formats do not encode patient information into the image file itself. Given the error rates noted above, we feel this is the most prudent course of action. This is a policy decision that we have made and one that we believe other healthcare facilities should consider. We also recognize that in some cases, CDs have the same images in both JPEG and DICOM format, but that is less common than having only non-DICOM images.

Another issue that we have seen with images on CDs is inappropriate compression of image data. While the vast majority of images are either not compressed or compressed using lossless methods, occasionally we do see lossy- or irreversibly compressed images on CDs. Even among those, the majority are compressed at a reasonable rate and do not pose a problem. However, there are occasional

cases where there are clear artifacts present on images, likely because there is no single compression rate that can reliably be applied to images which also achieves a reasonable savings.

As noted previously, we do see CDs that are not readable. More frequently in the past, this was caused by CD creation software which allowed one to eject the disk before "closing it." This problem seems to be less frequent now but we do see issues with CDs with fingerprints, being scratched, or otherwise becoming unreadable. We also see that there is some variation in readers across computers and we would recommend that one attempt to read a disk and on other computers.

An important policy decision is whether images from outside institutions should be archived. There is no one universal answer for every facility. We have seen that the average size for examination today is approximately 211 MB and that the average CD has approximately 2.3 examinations. We have noted that this trend is clearly increasing and as DVDs become more common, allowing greater storage capacity, the number of images as well as size of studies will likely increase. We are currently in the process of implementing a system in which any physician (radiologist or clinician) can request archiving as well as interpretation of an outside imaging examination. Those images not selected for archival or interpretation would be erased several months after the discharge of the patient.

The use of CDs for image exchange is pervasive, and a workflow that promotes high accuracy while not impeding clinical efficiency is critical. While there are efforts to develop systems for direct network-based image exchange, it is clear that CDs will be used for several years. Therefore, it is effort well spent to understand and address important issues in CD-based image exchange. It is also important to note that network transfer will also suffer from similar challenges, and that the process will be a bigger challenge. If a patient carries a CD, then it presents an opportunity for the patient to say "yes that is me." With networks, the usual mechanism relies on some sort of "profiling" to match identifiers between organizations. This may be highly reliable, but it is not clear that it is perfect—reports on accuracy are currently lacking.

Given the issues with data integrity, this is a good opportunity to emphasize that since it is a relatively simple problem to produce a CD, one should make the effort to do it well. The consequences of producing an errant CD are potentially very large and can only produce embarrassment for your facility. Another part of producing a high-quality CD is to have a viewer on it that is usable by most physicians. The IHE basic image review profile is attempting to improve the standardization of the user interface elements used in viewing images. We also emphasize here that 0.1% of CDs have information for more than one patient, which likely represents a HIPAA violation, and the penalties for breaches are becoming more severe.

Most would agree that CD-based image exchange is a suboptimal stop-gap measure. Transfer of images using the Internet seems a superior option [3], but there are important challenges in realizing that goal. Some of the challenges include privacy—when images are transferred by network, one must assure that *only* the individuals or organizations that *should* see the images *can* see the images. Encryption methods that protect the information during transfer is likely sufficient. The bigger challenge is assuring that only the right party receives the information, and that they know who it belongs to. HIPAA rules and regulations demand that this be done in a well-controlled fashion. The advantage of the CD over network is that the source hospital gives the CD to the patient, and the patient then gives the CD to whichever hospital(s) they wish, thus avoiding HIPAA concerns.

This model is now being applied to network transfer of images. There are now personal health records (PHRs) supplied by several vendors. These are designed to accept data from hospitals on a given patient. The patient may then review and give access to this information. Images can be transferred to a PHR capable of handling DICOM data. While there are some issues with this model—particularly in how a hospital might then "pull" the image data from the PHR into their system—just having a viewing capability from a PHR would be an advantage in many situations.

Conclusion

It is clear that network transfer of images will replace the CD as a transfer mechanism. However, because it is easy to produce CDs and more difficult to establish network-based image exchanges between unaffiliated providers, we will likely continue to use CDs as an image exchange mechanism for some time. Concerns about the privacy of network transfer are also a significant impediment to transferring images on the internet. Encryption methods can address much of the concern, but implementing encryption in a way that does not impede efficiency is necessary.

It is critical to get a process in place that promotes validation of data, one that ideally includes the patient in the process. In large groups and hospitals it is usually going to be most efficient and effective to get the examinations imported into the EMR as well as the PACS. This is less universal but often is going to be the most efficient mechanism. When you are producing CDs, be a respectful

member of the community and adhere to standards and strive to use a process that promotes high-quality CDs.

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