HOSPITAL, RADIOLOGY, AND PICTURE ARCHIVING AND COMMUNICATION SYSTEMS

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Images generated during the course of patient evaluation and management are an integral part of the medical record and must be retained according to local regulations. Digital Imaging and Communications in Medicine (DICOM) makes it possible for images from many different imaging modalities to be distributed via a standard internet network to distant viewing workstations and a central archive in an almost seamless fashion. The DICOM standard is a truly universal standard for the dissemination of medical images. Picture Archive and Communication System (PACS) refers to the infrastructure that links modalities, workstations, the image archive, and the medical record information system into an integrated system, allowing for efficient electronic distribution and storage of medical images and access to medical record data. This paper discusses the important elements to a successful PACS implementation in a practice, including how it interacts with other practice computing systems. *Veterinary Radiology & Ultrasound, Vol. 49, No. 1, Supp. 1, 2008, pp S19–S28.*

Key words: Digital Imaging and Communications in Medicine, hospital information systems, information storage and retrieval, medical image distribution, Picture Archive and Communication System, radiology information systems.

Introduction

IMAGINE THIS WORKFLOW. While in dialogue with a client in an exam room, a clinician orders a radiographic exam using the Hospital Information System (HIS). Within minutes, the order subsequently appears at the modality in a list of patients requiring radiographs that day. The radiology technicians select the appropriate patient from the list and conducts the study. Once the images are generated, they are sent to a central local server and the exam is automatically completed and charged in the HIS. By simply clicking the "view images" button under the images tab in the HIS the images appear in an easy to use browser-based medical image viewer, or on a Digital Imaging and Communications in Medicine (DICOM) workstation program on the local computer. Either viewing scenario allows real-time adjustment of contrast and brightness, magnification, the ability to perform measurements and many other image viewing features. That is the basic functionality of a Picture Archive and Communication System (PACS). There are no data entry errors, the images do not end up in cyberspace and the images are indelibly linked to the medical record and report. In addition, the images and reports are accessible from anywhere inside the local area network (LAN) and also potentially available outside the clinic network via the world wide web. Additionally, people do not have to navigate out of one application, open another, and then spend many minutes searching for the imaging exam within a different application.

For all sorts of reasons, that scenario, seemingly a reasonable workflow requirement in this age of computer technology is not commonly seen in veterinary practice.

Despite all that, medical image dissemination and archiving is much easier than it was in the early 1990s. The introduction of the DICOM standard and the transition from analog film to digital radiographic images has revolutionized the dissemination and archiving of medical images, allowing major improvements in imaging suite efficiency and productivity. For more information about the basics of DICOM see the article in this supplement.[1]

What is PACS?

PACS refers to the host of technologies that contribute to the creation, distribution, and archiving of digital images.[2] Typical PACS components include a digital imaging modality or device, a network with reasonable bandwidth, an archive device, diagnostic workstations, archive/routing software, and usually some interplay with the hospital or radiology information system. Bandwidth, defined as the rate at which information can be transmitted in a specific time interval, is important because medical image files are

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doi: 10.1111/j.1740-8261.2007.00329.x

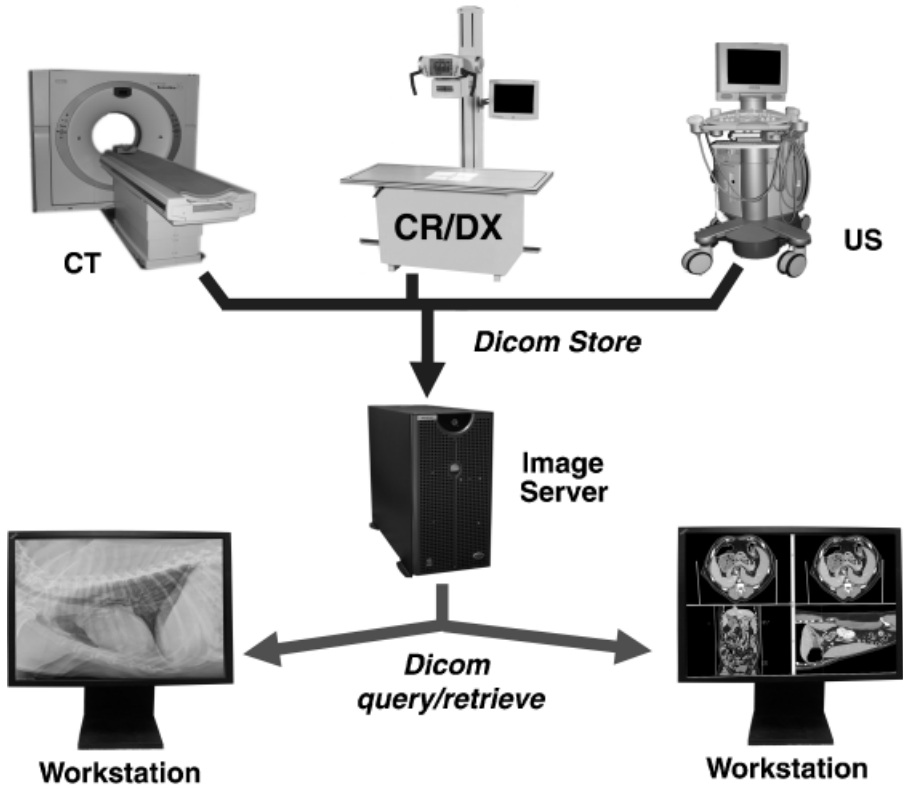

FIG. 1. A schematic of basic image distribution. The modalities send images to a central archive. Clinicians query the server and retrieve a copy of the study to the local workstation for viewing.

large, averaging on the order of 10–50 Megabytes (Mb) per study. For comparison, a digital photograph made with a digital camera may create a file of 250–500 kilobytes (roughly 50–100 times smaller). All modern PAC systems use the DICOM standard. The standard utilizes a network protocol that runs on top of the existing internet standard protocol (TCP/IP).

Potential Benefits of PACS

Managing and displaying images to clinicians in a timely manner are some of the biggest challenges in maintaining a modern clinical imaging suite. An integrated PACS can assist in the endeavor, offering many potential benefits, including:

- Direct cost savings associated with decreased consumption of radiographic film and chemistry, decreased processor workload/maintenance, less requirement for hard copy storage space, and decreased labor cost associated with film handling and distribution.
- Increased connectivity and integration between facilities and departments.
- Productivity improvements (less time spent looking for misplaced radiographs or ultrasound images, less time spent hanging/removing films, less time distributing films).
- Simultaneous viewing of the same images in multiple locations.
- Increased revenues through eliminating lost examinations and increasing effective capacity.
- Better image quality than analog film or thermal prints.
- Decreased time to interpret and communicate diagnoses.
- Provides an avenue for rapid consultation with specialists.

Basic PACS Configuration

In its most simplistic form, a PACS is comprised of one or more imaging modalities, an archive server and at least one viewing station connected on an isolated LAN (Fig. 1). Using DICOM as the image format and transmission protocol means that the server and viewing stations should communicate image data seamlessly regardless of vendor or modality.

Network and DICOM Connectivity

To establish communication between an imaging modality and server or server and workstation, the name, and network address of each component must be shared.

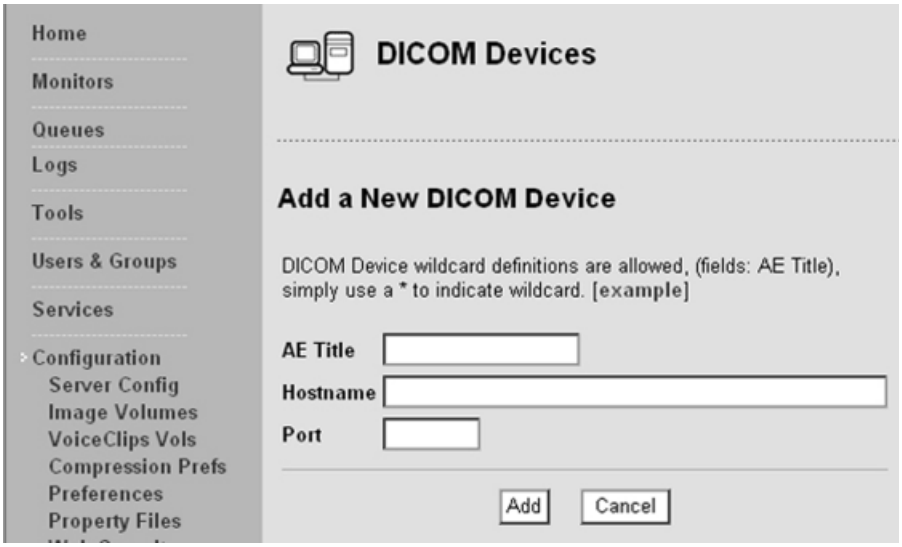

FIG. 2. Screen capture of part of a device table in image management software. Courtesy of integrated PACS provider, Amicas Inc., Boston, MA, www.amicas.com. PACS, Picture Archive and Communication System.

DICOM interconnectivity requires three simple address specifications. These include the Internet Protocol (IP) address of the computer or full registered hostname, the Application Entity Title (AE title), and an assigned communication port (Fig. 2). The IP address identifies the computer on the network and is unique to the computer. The AE title relates to the application or program on the computer, and again must be unique. The assigned communication port identifies the specific computer entry and exit port through which image information is allowed to travel when making a connection or receiving information from the network. This connection protocol is often termed a "DICOM Association." A computer might run more than one DICOM server program at any one time and in that case both the port and AE title for each application would be unique, even though the IP address for the application would be the same. For more information about networking, see the article in this supplement.[3]

Essentially, devices have initial communication, called a handshake, to ensure appropriate connectivity and compatibility before data transfer is attempted. Each DICOM device has a remote device table that allows the operator to load the IP address, AE title, and port of destinations to which the operator wishes to connect. Some devices require the DICOM address of the sender (SCU), while other devices can be configured to receive images from an unknown device, provided connectivity and compatibility parameters are correct. The latter configuration is often referred to as a promiscuous configuration.[4] DICOM workstation software usually continuously runs image management services behind the scenes so that image distribution and cataloguing can occur in the background and not interrupt the clinician using the viewing features of the program.

An important aspect of connectivity is ensuring the entire image study gets to the desired destination. If only part of the study actually arrived at the server or workstation, an incomplete data set would result in delays and potential misdiagnosis. Correctly designed software generates an error message and usually has a user adjustable, automatic retry function if there is a connection failure. This becomes extremely important when images are being sent beyond the LAN, where there is more chance of a transmission error.

Most modern LANs transfer data at 100 Mb/s or faster. New or upgraded systems transfer at speeds up to 1 Gb/s. Having a robust, fast network, and modern switches results in minimal delays in image transmission and minimal data transfer errors.

Imaging Modality

One or many imaging modalities can be connected on the network. Typical veterinary modalities include computed radiography (CR), digital radiography (DX), computed tomography (CT), nuclear medicine (NM), ultrasound (US), or magnetic resonance imaging (MRI). All these modalities should generate images in DICOM format and be able to send images to a remote server using the standard DICOM association (DICOM STORE SCU). Each should have a unique AE title, IP address, and port assignment. As has been stated elsewhere, not all so called DICOM-compliant systems are equal and it behooves the PACS administrator to ensure connectivity using a live test before purchasing and connecting a new modality to the network.

Image Archive and Server

The basic function of the image server is to receive images from the modalities, store the image files, and catalogue the studies in a database. There are many levels of image server software sophistication. In the most simplistic configuration, the clinician can query the server by a variety of search criteria (patient name, patient ID, study date, modality, etc.) Once the study is identified, the images can be retrieved from the server (an association using DICOM query/retrieve protocol). Copies of the images are transferred to the workstation for soft copy review. Ideally the clinician would like to view images without having to wait for image download that may be a minute or so depending on the size of the study and network bandwidth. This can be achieved by setting up autorouting rules in the server software, such that, as each study or image is received at the server, it is immediately sent to selected workstations.

In addition to providing query/retrieve functionality, many image servers can make studies available to the internet. This allows image viewing using a standard web-browser (most commonly, Windows Internet Explorer®) from any computer with a high-speed internet connection (see browser based viewers later in this article). As with DICOM viewers, there is considerable variability in functionality between vendors, particularly with respect to compression algorithms, transmission speed, viewer specifications, and reliability. The advantage of making the images web accessible is most apparent when images are viewed outside the LAN. The images are usually transmitted via http or https (standard internet browser, port 80, and secure internet browser, port 443) so there is usually less difficulty negotiating firewalls, unlike DICOM associations. Many vendors use a proprietary image transfer protocol and the images viewed on the web may not be in DICOM format. Provided the server software can respond to a DICOM query/retrieve command and distribute images in DICOM format on demand, how a vendor provides viewing via a web browser is, in the authors' opinion, less important than how well it actually works.

Server software should provide the ability to edit certain tags in the DICOM header. Even in the most controlled environments, mistakes in patient registration are made. Editing certain DICOM tags (e.g., patient number, patient name, exam description, date of birth) should be reserved for those with system administrator privileges. DICOM protocol requires that field editing be recorded by the application so that potentially malicious editing is documented. Usually there are various user profiles and the interface with the server is via http or https.

The server should be able to compress images using industry standard and preferably FDA-approved compression algorithms. Compression settings are usually modality specific and can be either lossless (no loss of digital data) or lossy (loss of digital data, but ideally no loss of clinical data). There are many potential options with respect to how the server software compresses and stores image files. Some vendors do not store the images long term in DICOM format but in other formats (e.g., jpeg2000). Provided the server can respond to a DICOM query/retrieve command, how the images are stored is not important. Methods of image storage do, however, become important with respect to redundancy and backups and if you decide to change PACS vendor. It is imperative that if you decide to change PACS vendor, that the images can be exported out of the old server in a format that can be received and imported by the new vendor's software. Realistically, one should maintain a copy of the original native DICOM.

Image Viewing

There are three basic methods by which one can view images remote from the modality.

Dedicated Medical Image Viewing Workstations

These are specific programs that are designed to allow the clinician to open and view medical images in DICOM format. Historically, image viewing workstations were expensive proprietary computer systems loaded with proprietary software. The DICOM standard has led to a proliferation of relatively inexpensive DICOM image viewing software packages that can be used both in the PC and MAC environments. DICOM viewing software of various quality is available as freeware from the internet or can be purchased, costing anywhere from approximately $500 to over 10 times that. These programs are designed primarily for Windows® operating systems but Mac OSX®-compatible programs are available. One of the most widely used Windows®-based programs is eFilm Workstation,* and a popular freeware, Mac OSX® program is Osirix.†

The basic requirements of a DICOM workstation are as follows:

- the ability to query and send image files to multiple DICOM devices, including other workstations;
- the capability to manipulate images (window/level, magnification, measurements, annotation, stack scroll, invert, rotate, etc.);
- a HIS/Radiology Information System (RIS) interface to link reports to the images;
- the ability to import other image types, such as jpeg and tiff, and convert them to DICOM;
- the ability to export single images or a complete series of images in jpeg, tiff, or movie file format;
- the functionality to allow dual monitor viewing;

*eFilm Workstation, Merge Healthcare, Milwaukee, WI.
†OsiriX - http://www.osirix-viewer.com/index2.html

- the ability to print to either a windows printer, or preferably a DICOM printer;
- the ability to create a CD containing DICOM files and an embedded DICOM viewer with basic image manipulation functionality.

Browser-Based Viewers

This configuration uses a web browser, usually Microsoft Internet Explorer®, to access images from a server that has this functionality. Usually the user is required to download a simple plug-in, a program that extends the functionality of the browser to enable manipulation of medical images. Historically, browser based viewers have had less functionality than dedicated DICOM workstations but medical image browsers are becoming increasingly sophisticated, including RAM-demanding multiplanar and 3D reconstructions for CT studies. This technology commonly employs Active X, Java, or Dot NET technology to distribute and display images. Often the images are not actually downloaded onto the computer but loaded into cache and deleted when that browser session is terminated.

Dual Function Workstations

The standard DICOM association, while robust and secure, poses problems with respect to firewalls and blocked ports. Some DICOM workstations have standard DICOM association capability and can access images via the web, either through the standard browser port (80) or via alternative ports. A common veterinary example of this is Image Channel, a web accessible portal available with Merge eFilm Workstation and Merge Fusion Server.‡

Alternatively, some DICOM workstations use http or https to retrieve DICOM files to the local computer and then seamlessly import the images into the same workstation software loaded on the local computer. The advantage of this configuration is that the images can be retrieved through firewalls that might have specific DICOM ports blocked (e.g., hotel room). The clinician receives the actual DICOM images (usually compressed, but compression settings can be changed) and the clinician has all the advantages of a dedicated DICOM workstation without the connectivity issues often associated with common DICOM ports.

A full discussion of viewer software and monitor selection is beyond this paper. There has been a number of studies comparing the diagnostic accuracy of commercial grade color monitors with medical grade monochrome monitors. Results have been variable. A recent study showed there was no difference in accuracy of observer performance for detection of wrist fractures with a PC (color monitor 1024 × 768) compared with a PACS workstation monitor.[5] A similarly designed study showed a nonstatistically significant (at 95%) trend toward higher diagnostic accuracy using a dedicated medical grade monitor vs. 2 megapixel (MP) 20 in. LCD monitor when evaluating thoracic radiographs for pneumothorax and wrist fractures.[6]

In the authors' opinion, there are many factors that influence the accuracy of softcopy viewing, including ambient lighting, extraneous distractions, functionality of viewing software, quality of graphics card, cathode ray tube vs. liquid crystal display, monitor viewing dimensions, monitor calibration, resolution, bit depth, and refresh rate. These are rarely optimized in the clinical setting and were optimized for both of the studies referenced above. Conducting the final interpretation of CR and DX images on small 1 MP color monitors that are not configured and positioned for optimal digital image viewing is not advised. For more information about image display, see the article in this supplement.[7]

Increased Functionality

The basic PACS shown in Fig. 1 can be expanded. More modalities can be added and more viewing workstations deployed. A DICOM printer can be added. Potentially an infinite number of devices may be added, however, in reality, at some point server processing speed, transmission bandwidth, and other technical limitations arise. Importantly, images can be transferred using a DICOM association to a destination outside the LAN, if the LAN is connected to the internet. Transmission beyond the LAN often requires adjustments to the institutional firewall configuration.

Figure 3 shows a more complex infrastructure. In this diagram, the veterinary practice has a LAN behind a firewall and is also connected to the internet. The practice is able to send images to a colleague for consultation using a DICOM association. The image server is able to distribute images to the internet for easy access via a browser. Also shown is another common configuration; the local server sends images to a remote archive for long-term storage and backup. Some remote archives can also distribute images via the web. There are many configuration options and this diagram is not a typical configuration but a composite of the most common configurations.

DICOM Services

Essential components of DICOM functionality as they apply to veterinary medicine include storage, query/retrieve and image display. Some DICOM services are not essential for basic functionality but can be important in larger practices. These include DICOM modality worklist and DICOM print. A worklist allows the HIS or RIS to communicate with the modality and automates the entry of

‡Merge Fusion Server, Merge Healthcare, Milwaukee, WI.

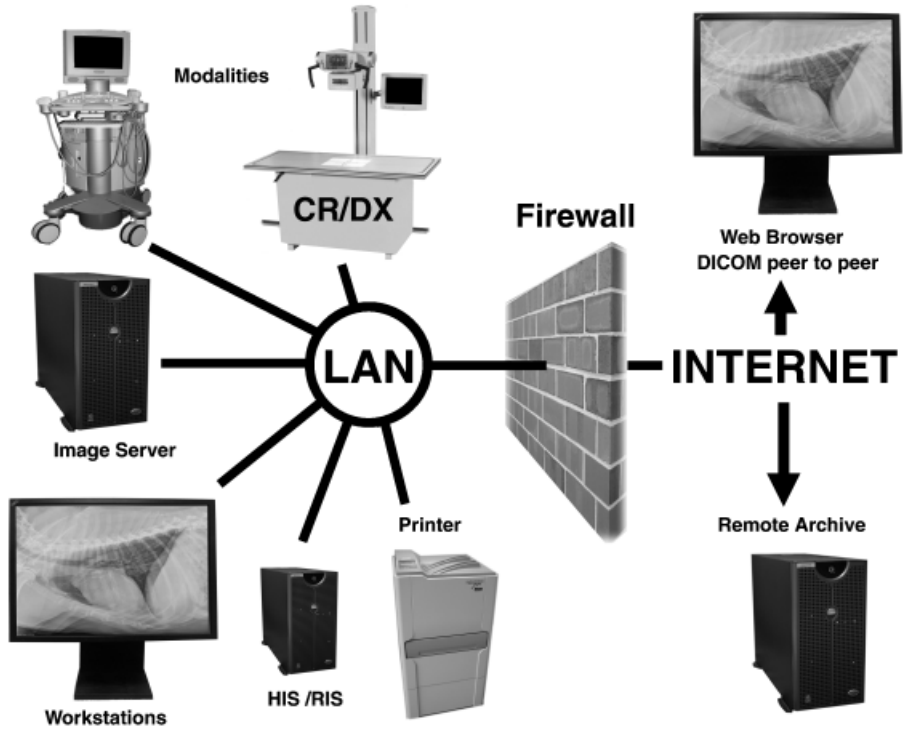

FIG. 3. A basic PACS. A printer has been added to the local area network and the HIS/RIS generates DICOM modality worklist that is distributed to the modalities. Reports from the HIS/RIS are accessible from the workstations. The LAN is connected to the internet via commercial broadband connection but protected from the internet by a hardware firewall. The studies can be viewed outside the clinic network, either via a browser or via a DICOM association. The images are also sent to a remote archive for long term storage. PACS, Picture Archive and Communication System; DICOM, digital imaging and communications in medicine; LAN, local area network; HIS, Hospital Information System; RIS, Radiology Information System.

patient demographic information for each exam. Additionally, the need may arise to generate hard copy images, and the DICOM print service class provides a method of accurately printing images on translucent film.

The DICOM requirements of a practice will vary with the needs of the practice and the type of imaging devices used.[3] Unfortunately, many DICOM services are not yet supported by some vendors of veterinary digital imaging devices and PAC systems. Determining what DICOM functionality is needed is an essential part of purchasing imaging equipment.

DICOM Compliance and Conformance

The term DICOM compliant is an all-encompassing term used by many vendors and is of little value. It is more important and accurate to identify which service classes (as defined above) are supported by a given imaging modality. This critical information should be available in the DICOM conformance statement associated with each piece of imaging equipment.

Storage and compression of ultrasound cine loops (multiframes), can be challenging for two major reasons. First, compression of cine loops can be problematic. Many ultrasound machines send compressed images, either lossless or lossy, by default because uncompressed studies (especially cine loops) can be extremely large and take a considerable amount of time to transfer to the archive or download from the archive to a DICOM workstation. Many PACS archives store files in a compressed format and sometimes cannot import files that are already compressed, particularly images compressed using nonstandard algorithms. Usually, some adjustment of compression settings on both sides (server and modality) can resolve this problem. Additionally, some PACS vendors have difficulty compressing cine loops from other vendors because the individual images within a cine loop may be presented to the PACS as though they were one image (rather than 250) and this causes problems for the compression engine. A second problem involves color palate selection. Ultrasound machine vendors have many options with respect to how the color flow overlay on the monochrome image is achieved and these issues can sometimes result in archive import failure. Currently, there is no well-defined standard for DICOM cine loops and this may be contributing to connectivity problems between vendors.

In addition to the general questions relating to functionality, one should ask prospective PACS vendors how their system handles cine loops, even if initially you do not envision using ultrasound in the immediate short term. The

importance of ensuring connectivity and adequate functionality before financial commitment cannot be overstated.

Integration of Medical Record Data and Images

To achieve optimal functionality, a PAC system does exist as a stand-alone technology. Ideally, workstations should have quick, direct access to patient demographics, histories, and reports. Additionally, images need to be readily accessible from the medical record in the HIS. Currently, most veterinary HISs do not have the functionality required to successfully integrate with a digital image environment. Larger veterinary practices that have recently invested in digital imaging systems are rapidly discovering the need for such functionality. Entering patient data multiple times via a keyboard or touch screen at a modality in a busy practice can result in a large number of errors. Many wasted hours can be spent locating and correcting misidentified imaging studies. A RIS or RIS module integrated with the HIS is the link for creating a fully functional digital environment. Ultimately, a RIS may be the most important component of a clinic's digital imaging infrastructure, particularly for outside consultation.

In the human medical environment, the HIS and RIS are usually independent software programs from different vendors, though this is not necessary from a functionality perspective. In human hospital systems, to negate the need for multiple entries of patient demographics when there are two independent systems (e.g., client registration with medical records and re-registration with radiology), patient registration data and exam order data are transferred from the HIS to the RIS automatically. This is done using HL7, an acronym for Health Language 7 or Health Link 7,[8] a standard for text communication between various systems used in the medical community. HL7 is considered to be the text standard equivalent of the DICOM standard for images. HL7 is commonly used to interface clinical laboratory software and the HIS in human hospitals. While this may be a viable option in large veterinary hospitals and university veterinary teaching hospitals, having a separate RIS and HIS in smaller veterinary practices adds an unnecessary level of complexity and expense. However, a module that generates a DICOM Modality Worklist from the HIS order and links images to the electronic medical record either via the accession number (automatically generated sequential number) or the Study Unique Identifying number,[1] can dramatically improve efficiency and data accuracy. Currently, a very small number of veterinary HIS vendors provide a DICOM modality worklist or have any integration between patient images and the HIS. In the authors' opinion, DICOM worklist significantly enhances workflow and essentially eliminates misidentified and lost studies. Some HIS vendors allow DICOM graphic files from the digital modality to be loaded into the HIS application database. Provided a customized viewer is engaged that allows adequate image manipulation as is done in a dedicated DICOM viewer, this is probably a satisfactory simplistic solution for small practices. In the authors' opinion, in larger practices, images should be maintained on an image server independent of the HIS application. In either configuration, it is important that the software allows easy transmission of studies via DICOM association to a destination remote from the hospital so as to allow external consultation.

The potential advantages of an integrated RIS and PACS are best realized when the RIS is web based. This takes full advantage of the networking and connectivity afforded by the internet. For example, a radiologist can access patient information, view images, file a report, and verify a report all from a remote location.

Workflow

A RIS module allows generation of a worklist for all requested, current, and completed imaging studies for that day (Table 1). This allows easy access to scheduling data and enables one to tell at a glance the status of a patient in the radiology suite (Fig. 4).

Accessing the exam history enables access to reports and images on all studies done on that patient (Fig. 5). From the report, links to the image server allow immediate browser based (or DICOM workstation) viewing of the images pertaining to that study (Image icon).

More than Just Radiographic Images

The infrastructure described above can be used to catalog and distribute any images and motion clips, pertaining to the medical record. The common graphic files (jpeg, tiff, bitmap) can be readily converted to a DICOM file, identified via DICOM modality worklist and sent to the archive for distribution and review in the same way as normal radiographic studies. Thus dermatologic, ophthalmologic, surgical, endoscopic, cytologic, or gross necropsy images could be readily linked to the patient file. The ideal RIS or RIS module should also be able to catalog and store non DICOM images including lameness movies, movies of neurologic examinations, endoscopic and laproscopic examinations, ECG tracings or even sound files of cardiac auscultations.

Accessing Studies Beyond the LAN

Many teleradiology services are available to the veterinary profession, providing a variety of services at differing costs. Hardware vendors often provide teleradiology options to augment CR, DX, and US hardware sales. One does not normally need to make an upfront financial com-

TABLE 1. Basic Digital Imaging Suite Workflow

Workflow in a digital environment showing the most basic integration between HIS/RIS and PACS

Order for radiographic exam logged in HIS or RIS

Exam scheduled in the appropriate room on appropriate imaging device (Resource)

RIS updates *DICOM Modality Worklist* with exam information, Patient ID, Patient Name, Gender, Age, Exam Description, Accession Number or Study UID

Operator queries *DICOM Modality Worklist* at the modality and selects the appropriate patient from a list of today's exams

The modality loads the DICOM header of the study with the patient-specific and exam-specific data generated from *DICOM Modality Worklist*. Image acquisition date and time and other header information are added by the modality

Images are generated and send to PACS Image Server for archiving and distribution

Images are autorouted to DICOM workstations based on preset autorouting-specific rules. Images distributed to the web and/or sent to remote archive

Images can be reviewed via the HIS/RIS—Using a hyperlink from patient file. Conversely, a hyperlink from any DICOM viewing software to the RIS allows the report to be viewed in a separate window while viewing the images both on the web and at a DICOM workstation

Systems using the study UID instead of accession number work very similarly. There are many more sophisticated variations of this basic infrastructure, including the Image Archive sending a message to the RIS that the study has been successfully received and automated charging of the study in the HIS once the exam is completed. In addition, various methods of automated study receipt verification are used in more sophisticated systems.DICOM, Digital Imaging and Communications in Medicine; HIS, Hospital Information System; PACS, Picture Archive and Communication System; RIS, Radiology Information System.

mitment for additional hardware and software, but if investment is necessary, it is important to ensure investment in an open architecture DICOM compliant system. This ensures the clinician the ability to send imaging studies to any colleague or specialist, using a standard DICOM association. Using open architecture DICOM systems prevents the user from being locked to a particular teleradiology vendor.

Security, Backup, and Disaster Recovery

Unlike standard graphic files, DICOM files have been intentionally designed to not be easily modified. These images are a component of the legal medical record and should only be modified by authorized personnel. Legal requirements with respect to the archiving of veterinary images differ between regulatory bodies and it is important

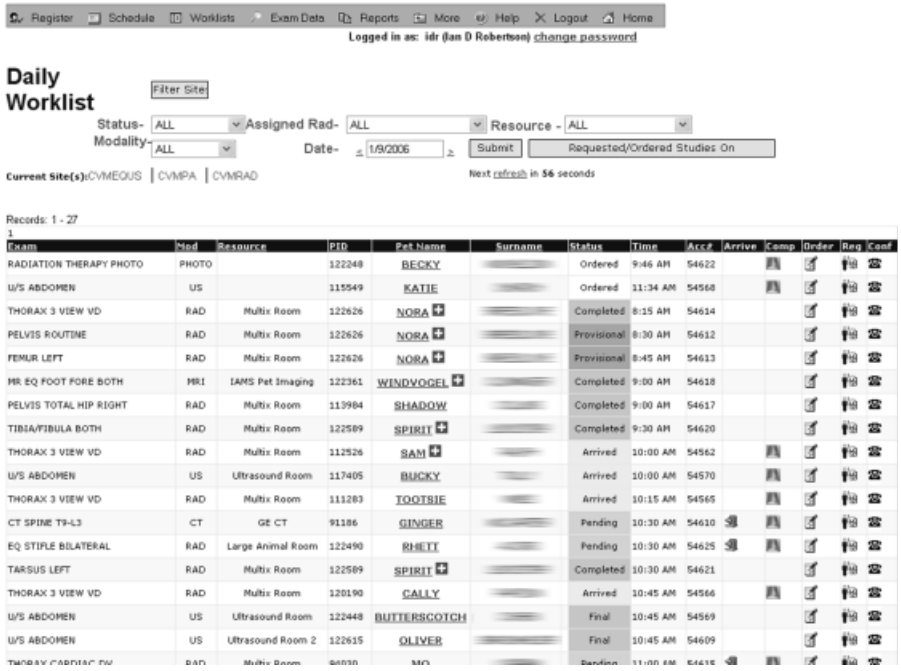

FIG. 4. Partial screen capture of a daily Worklist page. Courtesy of web-based RIS/PACS provider, Empiric Systems, LLC, Raleigh, NC, 866-367-4742, www.empiricsystems.com. RIS, Radiology Information System; PACS, Picture Archive and Communication System.

to adhere to local regulations. Data security is important, not only from a data corruption and data loss perspective, but also from an unauthorized access perspective. The veterinary profession is not currently under the same pressure as the medical profession to maintain client confidentiality Health Insurance Portability and Accountability Act (HIPAA) but it is likely this will change in the future.

A modern server with hardware redundancy (primarily redundancy of array controllers, hard drives and power supply) should be used. Image files and databases (just like medical record data), should be backed up to a second off-site device with hardware redundancy or burned to data DVD/CD or tape and those stored at a remote location. Consideration should be given to engaging a commercial entity to archive data and there are a growing number of vendors who supply offsite archiving services to veterinarians. Many modality hardware vendors also provide on-site and off-site archiving services. Some research of these

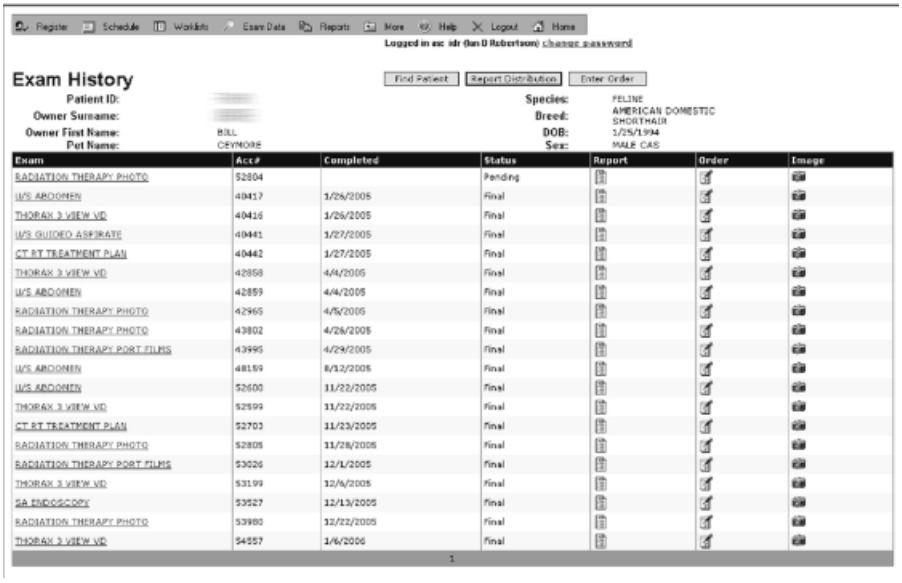

FIG. 5. Screenshot of an Exam History page. Courtesy of web-based RIS/PACS provider, Empiric Systems, LLC, Raleigh, NC, 866-367-4742, www.empiricsystems.com. RIS, Radiology Information System; PACS, Picture Archive and Communication System.

systems is recommended as there are major differences in functionality and cost between vendors. For more information about data storage, see the article in this supplement.[9]

Internet security is important to prevent hackers from gaining access to your system. A hardware firewall is mandatory for establishing a secure clinic network as is ensuring all current operating system security patches are loaded. When images are distributed outside the LAN, consideration should be given to file encoding or transmission via a virtual private network (VPN).

Summary

- The DICOM standard is the universal medical image file format and should be considered over all other image file formats.
- A PAC system is a host of technologies that contribute to the creation, distribution, and archiving of clinical digital images.
- Image distribution can be limited to a local area network or extended to a remote destination via the internet, either public or via a VPN.
- Electronic linking and seamless integration between images and patient data requires either the acquisition of an independent RIS or creation of a RIS module within the HIS. Currently few veterinary practice software vendors have responded to these challenges.
- Ultrasound generates some specific challenges with respect to archiving as many studies are cine loops and it is important that compatibility with equipment from other vendors is confirmed before equipment purchase.
- Industry standard practice with respect to data security, archiving, backup, and disaster recovery is mandatory and should not be overlooked. Seek advice and consider off-site services.

Definitions at a Glance

LAN—Local Area Network – A local area network (LAN) is a group of computers and associated devices that share a common communications line or wireless link and typically share the resources of a single processor or server within a small geographic area (e.g., within an office building)

DICOM—Digital Imaging and Communication in Medicine - The standard that defines the protocols for storing, querying, retrieving, and printing digital clinical images and allows for the exchange and viewing of these images

PACS—Picture Archival and Communication Systems—The combination of technologies that contribute to the creation, distribution and archiving of digital clinical images. The component technologies typically consist of the digital imaging devices, the computer network, an archive device, diagnostic workstations and archive/routing software

RIS—Radiology Information System—The stand-alone software or a component of HIS software that provides for entry, access and storage of patient demographics, signalment, histories and previous radiology reports and which links the patient file to associated images, usually stored on another server

HIS—Hospital Information System—Various types of commercially available software which form the backbone of a hospital's patient medical record system and often include numerous additional components including pharmacy management, billing, hospital patient census, etc

HL7—Health Level 7—A standard for communication between various data systems employed in the medical community that defines protocols for text information exchange.

DICOM Modality Worklist—A list of exams generated by the RIS that is queried and displayed on each imaging device. The list contains information on patient exams to be performed (usually that day) on that device as assigned directly by the RIS. Each list contains patient demographics, patient ID, accession number, study description and date and time information at a minimum.

Disclosure of Conflicts of Interest: The authors have declared no conflicts of interest.

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