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Enterprise Imaging: The Next Frontier in Healthcare Technology–A Liturature Review

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ABSTRACT

Aim

A review of the literature was performed to evaluate, review and discuss the imaging systems of picture archiving and communication system (PACS), vendor neutral archive (VNAs) and enterprise imaging.

Method

A search through the databases of PubMed, OvidMedline, Scopus and Embase was performed utilizing several keywords relevant to image storage in various combinations of "OR" and "AND". Articles were carefully assessed according to inclusion and exclusion criteria where only articles published in the last 10 years were obtained to collect recent information. Additionally, articles found from the reference sections of electronically sourced articles were also reviewed.

Results

The review revealed that traditional PACS suffer from several limitations of data storage, migration and maintenance. VNAs improve upon this situation by allowing images from different departments to be shared easily and extend this ability to in between organizations. Physical copies of images are no longer needed and applications such as teleradiology and mobile imaging are possible. Enterprise imaging attempts to provide a format that allows for organizations to govern the management of image sharing and storage between institutions using a set of 7 characteristics that define an efficient system.

Conclusion

Image storage technology has experienced several advancements in recent years. Traditional PACS imaging has allowed for image capture, viewing, storage and analysis but is unable to perform effective image sharing across institutions. VNAs have provided a system to surpass this limitation by normalizing proprietary digital imaging and communications in medicine (DICOM) formats used by PACS vendors. With the advent of new technology, enterprise imaging has been developed as a system that enables the management of multi-departmental and multi-institutional image sharing in one system.

Keywords

Enterprise imaging; PACS; Vendor neutral archives; Image storage; DICOM; Cloud PACS.

INTRODUCTION

Traditional picture archiving and communication systems (PACS) allow users to create images, store them in large data banks and then retrieve them for viewing or processing.[1] For many years this has been the standard system that health institutions have used to manage their image data within their imaging departments. However, each PACS vendor utilizes their own proprietary 'digital imaging and communications in medicine' (DICOM) standard format to increase their own system performance significantly.[2] Due to this, DICOM files from independent institutions are in different formats unrecognizable by other PACS. Vendor neutral archives (VNA) have been developed to address this fundamental issue. To remove the restrictions on health institutions, they normalize the proprietary DICOM format to allow for image exchange.[3] They have also improved on other issues of PACS including the removal of upgrading the entire system and in the case of cloud-based software the need for physical storage centres.[3] These developments have all lead to the evolution of enterprise imaging. Enterprise imaging offers improved efficiencies in data management through the creation of a comprehensive program intended to facilitate multi-institutional image sharing. The key characteristics of enterprise imaging and strategies to the implementation of the system are discussed and explored in this liturature review. Several white papers created by the Healthcare Information and Management Systems Society (HIMSS) and Society for Imaging Informatics in Medicine (SIIM) have addressed strategies and key characteristics that define what enterprise imaging is and how it should be implemented.

METHODS

For this liturature review we performed a search through the databases of PubMed, OvidMedline, Scopus and Embase. We utilized the following keywords: "enterprise imaging", "enterprise medical imaging", "PACS", "Cloud PACS", "Picture archiving and communication system", "Information storage" and "vendor neutral archives". These terms were utilized in various combinations using both "OR" and "AND". Combining search terms with 'AND', Pubmed produced 623 results, OvidMedline produced 53 results, Scopus produced 648 results and Embase produced 76 results. Articles were then carefully assessed according to inclusion and exclusion criteria (Table 1). Peer-reviewed research articles, journal editorials and seminal papers were included to provide a broad understanding of each information storage system. Only articles published in the last 10 years were obtained to collect recent information. Abstracts of articles were reviewed to assess the relevance before a full-text review was performed. Additionally, appropriate articles found from the reference section of electronically sourced articles were also reviewed. After a thorough review, 40 articles were selected to be apart of the liturature review.

Table 1. *Inclusion and Exclusion Criteria*

Inclusion	Exclusion
• Published between 2008 and present	• Published before 2008
• English Language	• Not in English
• Available in full text	• Not available in full text
• Reliable source	• Articles not focussed on information storage aspects of PACS, VNAs or enterprise imaging
• Focussed on either PACS, VNAs or enterprise imaging	
• Included challenges and issues associated with image storage systems	

RESULTS AND DISCUSSION

Review of PACS

For a modern healthcare institution, there is a high demand for data infrastructure that can provide quick, easy and reliable access to imaging results and store large and complex data files for patient records. PACS serves as a computer database that aids the storage and transmission of large and complex images from multiple imaging modalities.[1] The protocol behind the transmission and storage of images is dictated by a fundamental standard known as DICOM. DICOM allows for communication between medical imaging devices and the application server, which enables clinicians to locate and observe specific saved images.[4] The implementation of PACS in hospitals and healthcare organizations has greatly improved the imaging storage situation. PACS provides a secure, relatively portable and instant access to patient data across multiple imaging platforms.[5] This has reduced the costs associated with image storage and produced long-term savings from the elimination of films due to the online and digital format of images.[1,5] Furthermore, the workflow in radiology departments has greatly increased due to the simplification of patient data that radiologists can now access.[1,6] Additionally, improvement of PACS technology can support offsite teleradiology and computer assisted diagnosis (CAD).

Current Issues of Traditional PACS

PACS has streamlined many processes within a single hospital network, however due to its local nature and the huge amount of data it stores it has also produced issues with storage, maintenance and data migration that conflict with the requirements of modern imaging. Many articles agree that the large storage needed by PACS leads to varying issues in its efficiency.[2,3,5,7] A report by Maluf and Rajendran showed that 80% of data volume in electronic records were taken up by medical images which supported 60% of all patient diagnoses.[3] To facilitate this, a large PACS storage system should be implemented to maintain patient image history. However, a study by Costa et al[5] noted that imaging in cardiology and X-ray created huge volumes of data which also lacked interoperability as they were distinct PACS products.[5] Horii further expands this noting that other imaging subspecialties including ultrasound and nuclear medicine lacked proper visualization in PACS.[2] To make up for these shortcomings, PACS software and hardware can be upgraded to accommodate larger storage capacity and image visualization. However, upgrades can be costly, time-consuming and disruptive. PACS interfaces with many systems in the hospital ranging from hospital information systems (HIS) and radiology information systems (RIS) to billing and administrative systems.

System upgrades require interfaces to work cooperatively with each other however vendors on either side of an interface will only take responsibility for their side of the interface. This results in situations where new additional software interfaces do not match up with original software interfaces due to small differences.[2] When issues arise, maintenance must be carried out by the PACS vendor. However, these are specialized problems that require a dedicated PACS engineer. Thus, this requirement typically results in workflow disruption and loss of image and report viewing.[8]

Data migration of PACS images either from an old to a new system or in between healthcare institutions has presented many unsolved issues that affect the entire healthcare system. Each PACS system utilizes an individual proprietary form of DICOM formatting which optimizes their system performance.[2] The special DICOM formatting can then cause lengthy and expensive situations when hospitals need to transfer their PACS images to a newer system. Data mismatch requiring manual intervention can occur in this upgrading period when patients with similar names are regarded as the same patient.[2,3] Patient images introduced from a separate vendor into the PACS system can also hinder the data migration as they may contain their own private DICOM formatting.[8]

This issue is prevalent in the sharing of data across different institutions with different PACS vendors.[9] Some healthcare institutions still rely on the transmission of patient images through physical computer disc (CD) copies.[9] These disks are no longer being used in medical imaging storage.

In a study by Al-Hajeri et al,[10] they identified that radiologists determined a lack of support for mobile access and integration with other hospitals systems as a significant issue. They also pushed for web based PACS solution and mobile phone PACS access. Although these results have only been gathered from local hospitals in Kuwait, they represent that multi-institutional image sharing is an issue recognised internationally.

Cloud PACS

Cloud PACS is an evolution of PACS technology to provide a simple, scalable and accessible form of PACS for healthcare institutions. The utility is derived from cloud computing, where several widely distributed data centres house physical processing units that allow for virtualized processing and storage of information outside of the medical institution and accessible online.[11] Several articles and journal editorials observe that the integration of PACS to cloud based software would provide many benefits.[12-16] These include the multi-institutional access to patient image history, accessibility to remote radiologists, seemingly limitless data storage and elimination of investment into local data storage equipment and maintenance. Cloud PACS also opened the possibility of removing viewing software entirely and utilizing web-based architecture to view images on web browsers and mobile devices.[17-19]

Several previous articles also focussed on a functional aspect of the system that can be improved. This underlines that although Cloud PACS is useful, it is still far from perfect. Cloud PACS is not a local network and outsources the storage and processing power. In two articles published by Silva et al[5] they described methods to tackle latency and secure DICOM data relay issues.[15,16] Latency issues are due to huge amounts of image data that must transfer to the cloud *via* encrypted channels to maintain security.[15,20] Cloud providers will also have access to the confidential patient data which can raise some security and data privacy issues.[16] Because of this, providers have strict legal and ethical regulations they must abide by so that users as confident in their provider. However, this differs from private to public cloud computing services as the former is more well developed and is less accessible to the public.[21] Improvements proposed by Silva et al[5] may present advancements in the right direction however an article by Godinho et al[7] presents a practical challenge.[15,22] Implementation can only be justified by testing and investigation. As Cloud PACS manages communication from several geo-distributed locations, massive volumes of data will have taxing effects on bandwidth. Thus, if a test were to be achieved in a real medical institution setting, it may prove disruptive to day to day activity as some tests require saturating the network with requests.[22] Nevertheless, Godinho et al[7] also proposes a method to enable real world simulations without the disruption.[22] Cloud PACS remains a fairly new advancement to solving image storage issues but as the previous articles suggest, there are many factors that still present issues that need consideration.

Vendor Neutral Archives

VNAs are a recent advancement in information exchange technology that aimed to solve the multi-institutional problem that affected traditional PACS. Onsite or cloud-based VNAs made image exchange possible by normalizing the proprietary DICOM format of individual vendors for storage but still enabled images to be sent out in their original DICOM format.[3,23-25] The introduction of a universal viewer, or univiewer, removed the need to learn new viewers for each PACS. This improved physician preference, mobility and viewing flexibility. Additionally, upgrades to PACS to view different modalities, i.e. computed tomography (CT), magnetic resonance imaging (MRI), cardiology etc., was removed as different image modalities could each be supported and retrieved easily from VNA storage. Costs from maintenance and information technology (IT) support were outsourced to the vendor of the VNA, in the case of cloud-VNA this infrastructure cost was greatly reduced.[3] Thus, hospitals could support multiple PACS viewers and exchange images between institutions with different PACS vendors.

Workflow and efficiency of the imaging department were then greatly improved. Previously, physicians and radiologists would spend time to alternate and learn different PACS systems or unpack new image software to view outside images from a CD. With the aid of a VNA, physicians could continue using the PACS viewer they were most comfortable with and view images from different imaging departments easily. Furthermore, it allowed a best-of-the-breed strategy to picking new PACS viewers as radiologists could choose which system was the most suitable for them without being limited to a single consistent PACS across disparate imaging lines.[3,25,26]

Issues of VNAs

Although VNAs removed some significant concerns for using PACs, it brought several inherent issues. On-site VNA storage requires two data centres to be constructed and maintained with each centre containing a copy of the data. Thus, the initial infrastructure deployment cost could surmount the budget of a hospital.[27] It will ultimately come down to the long term plan of the health institute. If the institution intends to maintain a relationship to one PACS vendor or if they are too small to warrant this investment, then the upgrade may be unfeasible.[3] However, if purchased then the institution may go through their last data migration for all their images. As VNAs allow the combination of a multitude of PACS viewers, the institutional executive will be required to look after multiple PACS vendors. This is a disadvantage of the best-of-the-breed system selection as opposed to using a single PACS vendor for every image modality.[3]

In an article by Margolis, Westphalen & Haider,[28] they noted that the non-DICOM compliance of mpMRI image data was not supported by VNAs. The data they obtained from mpM-

RI combined with transrectal ultrasound could aid identification of prostate cancer. However, the metadata produced was non-DICOM compliant and urgent information on prostate cancer was still managed through CDs. This article highlights that certain non-DICOM compliant data files are not covered by VNAs and can present serious issues for the investigation of prostate cancer. Although a specific imaging combination is stated in this article it represents that VNAs are not infallible.

Articles by Bialecki et al[24] and Karthiyayini, Thavavel and Selvam were found that proposed additions to VNAs which could improve on inherent issues.[24,27] Bialecki et al noted that object storage technology could be an alternative to VNAs.[24] Object storage technology improved search queries to very specific information involving the patient, the type of illness and identification of pathology in the report. However, the article concludes by noting that the technology would be a better complementary add on to VNAs as it could be implemented in a non-disruptive manner as a powerful search engine. Although it was a case presentation, the article lacked results from a large-scale study and would require a follow up study to prove the practicality. Karthiyayini, Thavavel & Selvam presented an idea that had potential to be implemented in future VNA advancement.[27] Cloud computing enables a shared pool of computing resources for private, community and public sectors. By combining VNAs and cloud computing, disadvantages of on-site VNAs could be resolved. Placing both data centres into cloud-based storage could reduce the initial infrastructure deployment cost. Employing a platform-as-a-service format for the secondary data centre and a software-as-a-service format for the primary centre would enable the customer to only spend cost on an as-needed basis. This implementation is noted to provide flexibility for physicians to access images from anywhere with the interoperability of exchanging information between different institutions and departments. However, with the use of cloud-based software, security can become the primary concern as databases are now in the cloud as opposed to a physical on-site storage system.

Enterprise Imaging

In this transitional period of image storage technology, enterprise imaging represents a step away from traditional PACS and towards systems for multi-institutional image sharing. The onset of VNA technology provided a key foundation for providing a non-proprietary approach to archiving and data management that enterprise imaging can be based off.[29] However, from the literature studied in this review, there exists no one clear cut definition for enterprise imaging. Roth et al[30] identifies enterprise imaging as a set of strategies or initiatives to support clinical imaging workflows and management of IT infrastructure in an optimized format.[30] Petersilge provides a refined interpretation where enterprise imaging uses a central VNA to gather many hospitals and different care services lines into one single imaging system for image movements.[31] Another interpretation defines that it is the incorporation of all medical images into a single archive that is integrated into the electronic health record (EHR). However, the one agreed upon goal is for an image system utilized by health organizations to provide streamlined access to a longitudinal patient medical record encompassing both DICOM and non-DICOM images from disparate service lines. The function of enterprise imaging is similar to that of a VNA however enterprise imaging is distinguished as it represents a refined regulatory format for health organisations to implement and follow.

Seven characteristics of enterprise imaging: A collaborative workgroup made up of members from the Healthcare Information and Management Systems Society (HIMSS) and Society for Imaging Informatics in Medicine (SIIM) identified enterprise imaging as the next frontier in imaging systems. In preparation they developed a series of white papers to guide the implementation of enterprise imaging into healthcare organisations and identified 7 key characteristics of enterprise imaging.[30,32-36] However, of the series of 7 white papers only two focus on specific key elements, Governance and EHR enterprise viewer, whilst another introduces the characteristics.[30,32,33] It may be extrapolated then that these two key elements were highlighted as important aspects of enterprise imaging and that the other characteristics did not need as much guidance.

Governance: Governance is required to ensure care coordination and proper health information technology integration. There is not one unified definition or perspective of governance. Roth, Lannum and Joseph[32] state that although many articles have suggested the need for governance there are very few on the actual structure and implementation.[32] To provide a united definition, Roth, Lannum and Joseph and Roth, Lannum and Persons explain that governance is a decision-making body, framework or process that oversees and develops strategies for the enterprise imaging program.[30,32] The body would oversee the development of the agenda, technology, information, clinical use and financial aspects of enterprise imaging. Successful governance would involve active co-operation of clinicians in the implementation of clinical systems.[32]

Enterprise imaging strategy: Governance would then produce a strategic roadmap to the implementation of enterprise imaging. This would include financial considerations on what technology is available and what is required to facilitate the transition. The same would be done for redundant technology such as legacy viewers or PACS.[30]

Enterprise imaging platform: From the strategy, the infrastructure, modalities, devices and integration points should be provided. The central repository is often VNA based, however the organization may opt for a PACS if they intend on maintaining a single vendor. Several key considerations should be made such as whether the repository can handle DICOM and non-DICOM clinical images and video. The archive should be modality, modality vendor, specialty, service line and viewer agnostic. It should support standards-based access from DICOM, health level 7 (HL7) and web services. Furthermore, point of care modalities, handheld devices, software and image exchange gateways should be supported.[30] With this considered it can promote the importance of the EHR transitioning into a longitudinal medical record.

Clinical images and multimedia content: Enterprise imaging separates images into their use by the performing providers. Thus, instead of being categorized by modality, type of image or operational workflow it is based on 4 broad categories. These are diagnostic, procedural, evidence and image-based clinical reports.[30] Rather than being firm rules they are general categories that allow for one image to fall into more than one category. Diagnostic: images that confirm a clinical suspicion or provide differential diagnosis. Procedural: images captured before, during and after a procedure that act as a guide for surgical approach and documentation. Evidence: like 'procedural' it acts as documentation of the current state or progression of treatment and pathology. Image based clinical reports: where delivery of images contain textual information as well.[30]

EHR enterprise viewer: The enterprise viewer attempts to provide a single viewer to all images saved in the electronic health record or centralized archive.[30] To achieve this, the enterprise viewer must be a thin-client or zero client application that can be used on any device to display and manipulate images and documents stored in the EHR or separate centralized archives.[33] This allows access to diagnostic image creators, surgical specialties, general providers and patients.[30] However, as enterprise infrastructure allows the consolidation of many disparate service lines, specialty viewers from legacy systems can still be used depending on radiologist choice. Advantages of a thin-client or zero-client enterprise viewer include single viewer access to the HER, diagnostic image interpretation by specialties and clinics without a dedicated PACS, physician to physician collaboration, patient portal image viewing and medical education.[33]

Image exchange services: It is essential that enterprise imaging allows for inbound and outbound services of images including standardized DICOM and non-DICOM.[30] This provides the function of true multi-institutional image sharing. Images stored and indexed in VNA can be pre-fetched onto a local PACS in the original proprietary format for viewing.

Image analytics: By defining and standardizing all the imaging metadata, it provides a repository of data that can be analysed.[30] Thus, business and clinical reports can be formed from this data for study statistics and image acquisition patterns.

The white papers produced by the HIMSS-SIIM collaborative workgroup provide a detailed and informative guideline to the structure of a successful enterprise imaging format.[30,32,33] However, it can always benefit from specific studies into the actual implementation of an enterprise imaging format using the 7 characteristics as a template. As it stands, these white papers provide the current leaders of a healthcare organisation the foundation to understand enterprise imaging.

Workflow changes of enterprise imaging: A new form of imaging workflow known as encounter-based imaging may be introduced as enterprise imaging is adopted. However, this is dependent on the institution, what they aim to achieve and whether any departments would benefit from this workflow. Traditionally, order-based imaging is conventional in radiology. This followed a systematic format where referring physicians prescribe a specific standardized study to be performed at a radiology department to achieve a differential diagnosis.[34] The radiology department would receive the order, obtain the image and the radiologist would send their diagnostic report back to the physician. However, certain departments that acquire visible light images or recordings may not fit into this workflow. For departments such as dermatology, emergency of some surgical settings, they may be required to acquire photographs of moles, skin lesions or moles on presentation of the patients.[34] As this is not known before the patient arrives an order cannot be set prior. Furthermore, the orders that use standardized general locations such as 'Humerus' in radiology may not be applicable when the mole is in a more specific location of the upper arm. With the potentiality for multiple moles in dermatology it would be highly inefficient to order multiple image orders of different body specific locations. Encounter-based image capture would allow image acquired by the dermatologist to be manually inputted into the patient's electronic health record allowing for ease and specificity. However, the risk of misspelling patient or study information exists with manual typing. For encounter-based image capture to function properly there needs to be mechanisms that enable delivery of image specific information as part of the image metadata such as body part identification, acquiring specialty or procedure description. As it stands, encounter-based imaging is not a well-documented or well implemented system in EHRs. As only one white paper produced by Cram, Roth and Towbin exists that outlines the potential uses of an encounter-based workflow, more research into the efficiency of this system in departments such as dermatology is required to highlight the benefits.[34]

Different applications of enterprise imaging: Enterprise imaging is not one single system format, , preferably it is an idea on image sharing and storage optimisation as demonstrated by Bian, Topaloglu and Lan and Erdal et al[35,36] Bian, Topaloglu and Lan discuss the development of an enterprise imaging repository (EIR) for implementation into a nuclear medicine department at the University of Arkansas for Medical Sciences (UAMS).[35] The need arose from the issue of poly ethylene terephthalate (PET)/CT storing huge amounts of images to an old PACS server that was cost inefficient. The equipment identity register (EIR) utilized a universal web-based viewer, integrated into the ADT (Admission, discharge and transfer) system of UAMS and accepted a variety of image formats including non-DICOM standard formats. This followed several characteristics of enterprise imaging including: Enterprise imaging platform, enterprise viewer and image exchange services.[30] As evidenced, the EIR did not utilize a VNA but followed the stratagem of storing all medical image files in a central location with ease of access and sharing. However, the article only covered images created in a nuclear medicine department of one organization. It can be further improved by testing the technology on different departments and reviewing the processing of non-DICOM standard images in another study.

Erdal et al[36] demonstrated a study on the development of radiology and enterprise medical imaging extensions (REMIX) platform at the Department of Radiology in The Ohio State University Wexner Medical Centre.[36] The REMIX system was a collection of hardware and software modules that presented custom code and add-ons to vendor-based software. It aimed to enhance cancer related imaging and research by mining cancer radiomics data and providing a platform to build predictive models relating image features to tumour phenotypes. Although REMIX does not strictly deal with conventional imaging it presents a unique adaption of enterprise imaging in research that allows for datasets of multiple institutions to be extracted and analysed. However, the study provides a proof of concept and for the functionality to be fully realized, the study should be tested again involving datasets of multiple hospitals.

Challenges and limitations of enterprise imaging: Enterprise imaging although useful is not without faults. Several articles have identified issues that range from technical considerations to workflow issues. HIMSS-SIIM have attempted to provide solutions to challenges identified in their white papers but these remain as guidelines.[37,38]

Although a minor issue, there are some image producers who do not appreciate the accessibility of patient images or the integration into a longitudinal medical record. These image producers believe that only the diagnostic report is the significant product and that images are only important to the diagnostic interpreter.[31] It may be interpreted as a natural stubbornness to change and an issue that does not require much intervention. A hurdle that every organization transitioning to an enterprise imaging format is still data migration.[2,3,8,39] However, it should be reaffirmed that although it may be costly and time consuming, if transitioning to cloud based or VNA stage it may be the last data transfer ever.

Several functional issues of enterprise viewers were raised by Roth et al[33] Although enterprise viewers can support a majority of images they cannot support every single format today and formats developed in the future. Thus, they should not be termed 'universal viewers' as it carries a different connotation. Another issue is that some enterprise viewers may carry basic to specialty image interpretation tools whilst other viewers only support necessary tools.[33] It may be a reasonable conclusion then that the enterprise viewer is more suited to a general group of users and will not be able to suit every single provider. Furthermore, different viewing environments may be required by radiologists or cardiologists and an enterprise viewer may not present images in an ideal state without the need for manual intervention.

Some technical limitations are identified in a white paper by Clunie et al[37] They identify that with diagnostic imaging, some ECG systems will maintain raw data in proprietary formats and only allow a post processed image of the waveform through. Similarly, ophthalmic imaging devices do the same but only allow software analysis to be achieved through vendor specific software. Other imaging specialties including obstetrics and gynaecology present another issue with lack of vendor conformance on DICOM standards. This further accentuates that some specialty groups can raise issues in enterprise image storage as seen in previous studies.[9,28] Additionally, linking all imaging to the same procedure in situations where both DICOM and non-DICOM imaging are used has proved difficult to achieve in the electronic health record (EHR). These issues highlight that there may be a reluctant acceptance that not all raw image data can be acquired and that the EHR requires further refinement.

Enterprise imaging aims to provide acceptance of non-DICOM images, however visible light images or recordings can create unique issues for effective image storage. Visible light (VL) images involve images captured on a camera in settings such as dermatology or emergency to document physical appearances of skin lesions or wounds respectively. However, in integration to enterprise imaging storage, VL requires the support of true colour images, different metadata requirements and acquisition workflow as opposed to conventional radiology.[37] Images that undergo lossy compression can lose accurate detail and start to blur on review. Lossless compression can preserve this image information but will result in larger file sizes.[37]

Towbin et al identifies seven workflow issues associated with visible light images.[38] Workflow: organisations will be required to decide on whether an order based or encounter based image capture workflow system should be utilised. As some departments, such as dermatology, do not know whether they will take an image prior to patient presentation or may be required to take multiple pictures then order based image capture can prove inefficient.

Patient identification: Camera images will typically lack unique patient identifiers inside the image. Solutions such as patient identifying stickers or imaging patient identifiers before and after the image acquired can be used in some situations. However, this method is prone to human error and cannot be used in situations where a sterilised field is required.

Information of the image: Measurements that could be typically taken with normal viewers are redundant in cases with photographs as pixel spacing and zoom factor are not standardized. To combat this, if a measurement tool such as a ruler is in place then measurements can be taken. Colour standardization will also be an issue as lighting, shadowing and camera settings will vary with every image. Thus it will be difficult to colour correct on a computer. Similar to before if a physical tool such as a colour wheel is introduced then the computer can recognize this tool and perform colour corrections efficiently. However, physical tools present in image will suffer the same problems as Patient identification.

Reporting: Bi-directional image and report viewing will be required as photographs can often be taken after the report in dermatology as opposed to being taken before in conventional radiology. This allows for easy image and report association and viewing. Metadata: essential information such as body part region, department and procedure description is lost with VL images. To counter this effect, if the body type and study type information is included in an encounter based image workflow then some important metadata can be retained.

Legal concerns: Photographs that document child abuse or sexual assault can bear privacy issues. In this case the organization will need to create permissions for access but image sharing will magnify this issue.

Mobile viewing: Mobile viewing with the advent of mobile devices such as smartphones, more and more physicians are using their devices to document pathology. This raises a range of legal issues as their phones become carriers of patient sensitive data. However mobile applications could be created to facilitate this.

Clunie et al and Towbin et al have highlighted a variety of technical and workflow issues with visible light images.[37,38] However, both these white papers are unable to provide solutions for each issue. Solutions provided are general and although these papers serve to guide organizations on what issues they may face, further research may be required to solve specific issues raised.

An exciting challenge presented by Dinov describes how big healthcare data lacks any reliable means for data analysis or research.[40] As enterprise imaging will gather significant amounts of data and only continue to expand in size and complexity, data analysis may be problematic. As previously noted by Erdal et al,[36] data analysis can provide models for pathology and image analysis. However, although Dinov is hopeful that analysis technology will encounter great advances in the future, enterprise imaging will present unique issues of associating DICOM and non-DICOM images for collaborative analysis.[40]

CONCLUSION

Technological advancement has allowed for significant changes in the healthcare imaging industry. Multi-institutional image sharing is no longer a limitation for many healthcare organizations who are still using a traditional PACS model. With the arrival of enterprise imaging, a format to achieve accessible healthcare imaging to both radiologist, radiographer and patient is possible. However, the transition to an enterprise imaging model is a great or deal that an organization must be willing to undertake before reaping the benefits.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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