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6 Sharing Imaging Data

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Key Points

1. Standardization is key in sharing imaging data to ensure high levels of interoperability.
2. Imaging data should be available to all stakeholders, from radiologists to patients.
3. Social Media use should be avoided and, if necessary, should be used with caution.

6.1 Introduction

Why is sharing imaging data important? Well, radiology is images and there are many reasons to share them (Fig. 6.1). In most cases patients are sent by a referring physician to the radiology department for diagnostic imaging so that radiologists can assist them in making a diagnosis or advise them in making decisions about the treatment. First, images and reports need to be shared to facilitate mutual communication, which means that they have to be accessible and viewable in other departments within the same institution. Second, referral of a patient to other hospitals for example for further treatment or to obtain a second opinion also requires transfer of medical data, including the radiological images. Third,

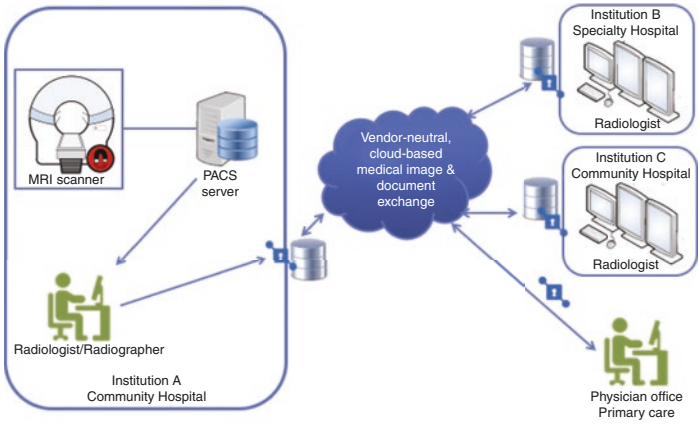

Fig. 6.1 Reasons for image sharing in radiology

nowadays most institutions allow patients to view their images from outside the hospital, which also needs the transfer of image data to a patient portal.

Besides patient care, image sharing is important for research and education. New developments like the training of algorithms with Deep Learning can only be successful when large (anonymized) image datasets are made available.

A guideline to safely and securely share imaging data can be found in the Digital Imaging Adoption Model (DIAM) of the Healthcare Information and Management Systems Society (HIMSS) Analytics [1]. The DIAM was developed by HIMSS with the support of the Society of Imaging Informatics in Medicine (SIIM), the European Society of Radiology (ESR), and the European Society of Medical Imaging Informatics (EUSOMII) to aid imaging departments in identifying and adopting the right digital strategies, with the main intention to improve health outcomes for patients. The DIAM defines 8 stages (0–7), of which stages 0–4 require hierarchical incremental improvement of the digital imaging adoption in the hospital. Stages 5–7 are non-hierarchical and can be adopted in any order. Of particular interest to the topic of this chapter is Stage 7 of the DIAM model, which concerns advanced health information exchange and patient engagement. A quote from the DIAM states as follows:

> *The majority of image producing service areas are exchanging and/or sharing images and reports and/or clinical notes with care organizations of all types, including local, regional or even national health information exchanges based on recognized standards.*
>
> *The application(s) used in image producing service areas support multidisciplinary interactive collaboration.*
>
> *Patients can make appointments, access reports and images as well as educational content—specific to their individual situation—online.*
>
> *Patients may be able to electronically upload, download and direct the sharing of their images* [1].

The points in the quote basically cover all previously mentioned aspects of image data sharing. In the coming chapters we will cover these based on three different levels of image sharing:

1. Sharing within the enterprise
2. Sharing with other health-care institutions
3. Sharing with patients

After these three different levels, special attention is given to Social Media as a relatively novel method of sharing medical images by health-care professionals and patients.

6.2 Sharing Within the Enterprise

6.2.1 From "Come Over and Look!" to "Look into My PACS!"

In the early days of radiology, when a film-based operation was still in place, only one physical copy would be available of any radiological examination in the vast majority of cases. In order to view the images, the referring physician had to either visit the radiology department so that the findings could be discussed with the radiologist or ask someone to transport the images manually to him/her. Not unfrequently the images got lost because they stayed in the office of the referring physician, who forgot to return them to the radiology department. An alternative way to share images more safely at that time was making a physical copy of the film, which was quite expensive and time-consuming and therefore infrequently used. The lack of digital copies often resulted in missing films, which made it impossible to compare the old images with new ones in case a follow-up exam was made for the same patient. So, the physical film was a far from optimal format to share images within and certainly outside of the hospital or with the patient.

After the conception and progressive implementation of the Picture Archiving and Communications System (PACS) during the first decade of the new millennium, the "come over and look" approach to show images to referring physicians slowly changed into: "Look into my PACS." The images archived in the PACS were either natively digital or digitized, so they could be made available to multiple people at the same time without the risk of missing films. By making digital copies (e.g., on a CD or DVD), images could be distributed outside of the hospital. This procedure became quite popular (and unfortunately still is) for asking second opinions to experts outside the hospi-

tal, or when transferring patients elsewhere for diagnosis and/or treatment.

In the early phase of transition to the digital radiology department, it was necessary to install fully equipped radiology workstations that were hooked up to the radiology PACS in different departments throughout the hospital, sometimes by establishing physical connections with dedicated cabling. Besides the rather costly aspect of such solution, it was also rather unpractical since the physicians were only able to access the images at a limited number of locations. A desire for a more institutional-wide instead of local or departmental access to imaging data eventually led to the development of web-based systems. These systems made it possible to provide access to the images from any PC throughout the hospital, although in most cases the image quality on non-diagnostic or the so-called referral monitors was less. The essence is that the web-based solutions made it possible to review and discuss images anywhere in the hospital and even from outside (e.g., from home) by providing secured web-based access. For diagnostic purposes however, the radiologists kept using workstations with high-resolution medical screens. The, often separate, web-based systems commonly required copying data from the PACS to the web environment which could cause delays in the availability of imaging data. At some institutions, this delay was intentionally extended to avoid sharing images outside radiology before the report was dictated and finalized.

During the past decade, the digital environment slowly evolved into an enterprise-type digital archiving system or PACS, which is a more integrated solution providing role-based access not only to imaging data but also to the Electronic Medical Record (EMR). This way images can directly be accessed through the EMR, which is usually done for reviewing purposes. In radiology departments however, a separate PACS is still being used since the diagnostic workstations can offer more features and post-processing tools for diagnostic purposes. Depending on the system that is used, the Radiology Information System (RIS) can either be separate, or integrated into the EMR.

An important aspect of this whole transition was the interoperability between different (computer) systems. In the early days,

most digital systems within a radiology department were working separately and simply could not communicate or exchange information. Although digital image output was possible from any modality, there was no exchangeability of data between equipment from different vendors. The images coming from a vendor-specific modality or machine could not be post-processed on an image post-processing station from another vendor. Companies had their own protocols and image formats, and images had to be archived on offline media such as physical hard drives. The introduction of the Digital Imaging and Communication in Medicine (DICOM) standard made it possible to share images throughout the enterprise, and to create greater interoperability between all devices adhering to the DICOM standard. Although in the beginning some creative solutions were required, the advantages of the introduction and implementation of such standard were quite obvious.

Further developments in medical imaging informatics besides the DICOM standard, such as the creation and international acceptance of guidelines for Integrating the Healthcare Enterprise (IHE), lead to a situation enabling the digitization of the entire radiological workflow, which evolved into the enterprise-PACS of today, in which images are instantaneously accessible from anywhere in the hospital, from the consultation room to the operation room. It also allowed the introduction of more specialty-dedicated postprocessing techniques, which can be applied not only for diagnostic purposes but also for treatment of patients, for example, 3D printing of patient-specific prosthesis based on radiological images.

6.3 Sharing with Other Health-Care Institutions

6.3.1 Portable Media

Almost simultaneously with the development of data sharing techniques within the own health-care institution, attention was drawn to the possibilities of sharing data with other institutions. Where in a period based on physical film or in early digital stage,

either the original films or copies had to be sent to another hospital, the digital transition gave onset to a growing demand to do this via a digitally portable medium. As a consequence, the digital sharing of imaging data by using writable CD and later DVD was launched. The reason for this was simply that it was the most common portable medium in consumer electronics, which was also supported by the Microsoft Windows platform, making it an easy to handle and cost-effective method. The CD/DVD medium was easier to handle and read externally in comparison with the vendor proprietary Magneto Optical Disk (MOD), which was pretty common in earlier days and often used in computers attached to imaging modalities such as CT or MRI.

Besides this benefit, there were also some challenges with using CD or DVD portable media [2]. First of all, it was platform-dependent, which means that a CD burned on a Unix computer would not be readable on a Windows computer. Secondly, DICOM viewing software was required, resulting in the circulation of many different viewers that also were platform-dependent. Consequently, the CD or DVD could not always be read at the receiving institution's computers. Another issue to be dealt with was (and sometimes still is) the fact that computers at the receiving institute would not allow to start a (required) DICOM viewer embedded on the portable media because of security issues. An even more important drawback of using CDs or DVDs is the fact that the patient privacy is at stake because such physical media can easily get lost or misplaced during transportation or sending by conventional mail. Furthermore, it is known that these portable media show quality degradation with time and through sunlight exposure. During the past few years, with the rise of the USB-storage devices and cloud-based solutions, CDs and DVDs have reached a phase of extinction also in the consumer market. Because of this, finding a computer equipped with the required hardware to read the CD/DVD is becoming challenging.

Portable media are therefore slowly losing ground on the one hand because with intermediate solutions such as the uploading of CD/DVD-content into a PACS, issues-related accessibility and security of the data have to be dealt with [3–5]. On the other hand, because the increasing occurrence and acceptance of secure cloud-

based solutions and region or country-wide digital networks are now accelerating the complete replacement of portable media.

6.3.2 Advanced Health Information Exchange

As shown in the previous section, the progressively decreasing support for portable media can be mainly explained by the emergence of other solutions to share imaging data between institutions, based on internet connections between the institutions used for fully digital data transfer over the world wide web. These digital solutions have caused an increasing concern about privacy, data safety, and image quality (Fig. 6.2).

Nevertheless, in the consumer market not only private persons but also enterprises have become accustomed to moving many types of data via the internet (including but not restricted to music, photos, videos, and financial information) in daily life. Apparently, society finds this means of information exchange efficient and desirable, and this type of exchange of confidential information has reached a reasonable level of trust. For health-care services there is also a tremendous level of progress in cloud technology, but the main challenge still lies in ensuring the highest level of security and confidentiality required for sharing patient data.

One of the possible cloud-based solutions is PACS as a Service (PaaS), where the cloud environment is used to transfer images to

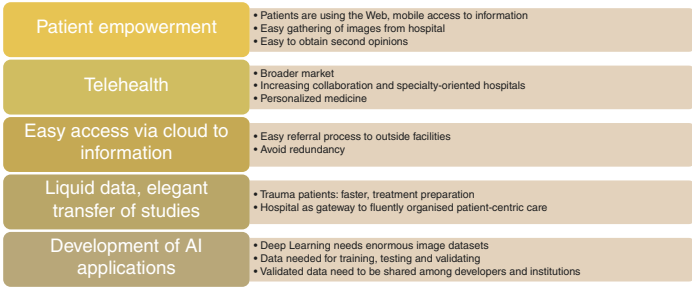

Fig. 6.2 Important topics concerning Privacy, Data Safety, and Image Quality when using digital sharing of (imaging) data

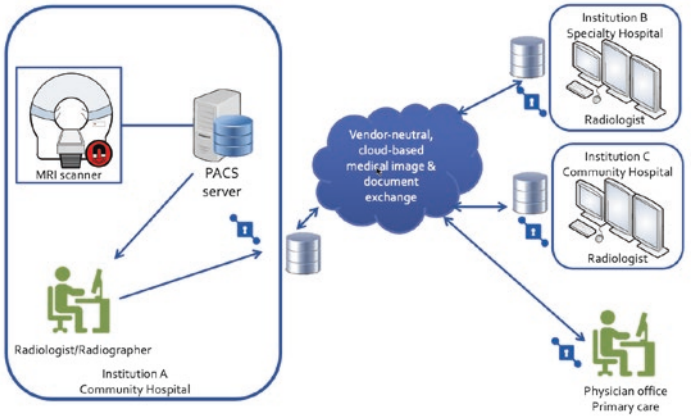

Fig. 6.3 The PaaS environment with a vendor-neutral exchange environment in the cloud servicing both the producer of the data and multiple consumers

different institutions and clinicians in physically separate locations (Fig. 6.3).

Cloud-based solutions play an important role in fostering better models for fluent exchange of images and information. The interoperability profiles, Cross Enterprise Data Sharing (XDS) and XDS in imaging (XDS-i), published by Integrating the Healthcare Enterprise (IHE) can be used to establish secure connections between PACS, RIS, and EMR systems. Intelligent pre- and post-processing of imaging data is possible, with direct integration in clinical workflow.

Driven by technological developments, connectivity also becomes more meaningful when information can be used for data mining, data processing, artificial intelligence, and cloud-analytics capabilities.

6.4 Sharing with the Patient

The availability of digital images and internet-based solutions to share such data also increased the demand of patients to get access to their own health-related data, including medical images. This demand has also been integrated into existing regulations for sharing health data, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States, which allows patients to demand access to their medical images. In the European Union, the General Data Protection Regulation (GDPR) entitles patients the portability of their personal data and the right to be forgotten, which both also include health data. This means that patients have the right to obtain access to their data, and also to withdraw or remove them on personal request. A question that might arise is: why should a patient obtain their own imaging data from their hospital? On RadiologyInfo.org, a website providing information about radiology to patients it is stated that obtaining and storing copies of their own medical images may be helpful for patients who are [6]:

- Seeing a physician for a second opinion (also, e.g., by using consumer websites like www.diagnose.me/ or www.crowdmed.com).
- Being referred to a specialist.
- Undergoing treatment for cancer or a medical condition that requires monitoring over time.
- Having imaging performed at a new facility.
- Keeping a comprehensive personal health record (PHR).

A 2013 study among 1000 US-based patients showed that 61% of patients wanted to share their medical images with family members and friends, and 88% wanted to share their imaging data with other physicians. Only 4% of respondents would not share their own images [7]. At the same time the study also showed that only 50.2% of the respondents had actually received a copy of their images. Of these data recipients, one-third got less than 25%

of the images taken and only a quarter received more than 75% of the images taken.

Surprisingly, still at that time—in 2013—66% got their images in the form of hard copies, and 27% got copies on portable media such as CD, DVD, or USB. We can safely assume however that this number has now progressively shifted to a level where a majority of the patients will receive digital copies in some format (either on portable media or through online access), although in some countries physical film or another form of hardcopy is still common practice.

Nowadays a sharp increase in the use of patient portals and other cloud solutions, such as Personal Health Records (PHRs), can be observed [8]. In such a patient portal, which usually is a cloud-based solution, patients' access to images can be guided and linked to a clinical consultation. In this way, an explanation can be obtained about the results or findings of the radiology examination, avoiding misunderstanding of the images or the radiology report. This guidance of the access to the imaging data and other data, such as lab results, is important because, although radiology reports are among the most difficult parts of the medical report for lay people to understand, they are also one of the most frequently visited sources of information by patients whenever available [8].

The advantage for the patient will be that all his or her health information (of a particular health-care provider) is available as part of an online and easily accessible single environment. Many systems allow access to the imaging data using web browser technology in a so-called zero-footprint viewer, allowing viewing of the (imaging) data through a browser in a secure manner, independent of any device or PACS software or hardware.

In countries such as Belgium, the large majority of hospitals provide secure web-based access to the radiological images, not only to patients but also to referring physicians or general practitioners. Images and reports can be accessed, downloaded and even shared by dedicated and secured mobile apps. Referring physicians from outside the hospital can even see all their patients' results through such platform, and compare the new results with the previous ones. This way both patients and physicists have

more possibilities to obtain second opinions, and hospitals can transfer patients including their medical images more easily elsewhere for treatment.

Important aspects to consider when sharing (medical imaging) data with patients are the restriction of access to data, and the security and privacy of the platform. The environment provided needs to be such that patients only get access to their own data with the ability to share access with family or other representatives and specific health-care professionals. But also, this access should be restricted on a need-to-know basis. Not every person granted access should automatically have access to all the available data. This access policy should be easy to set up and configure for the patient. The environment should also be secure to avoid unauthorized access or data extraction by malware or hackers. Finally, patient privacy must be respected and guarded at all times.

6.5 Social Media Use in Sharing Imaging Data

A relatively novel method of sharing imaging data that eventually might be hampering the aspects of data security and patient privacy is Social Media (SoMe). When patients have access to their own images, they may be inclined to share them on non-secured platforms (e.g., Pinterest, Snapchat, Instagram) resulting in sensitive data becoming available in the public arena.

Medical doctors and residents have also been reported to use SoMe such as WhatsApp, to obtain quick answers on questions related to image findings, for example, during on-call services. Medical residents or trainees send images and other information through SoMe to their supervising specialist, with the intention to obtain a second opinion or to have a diagnosis confirmed in cases of doubt.

A study published in 2015 showed that 50% of medical doctors would use their smartphones to share images, and almost 50% also admitted to send patient-related clinical information with their mobile phones, using various messaging apps, e.g., to send a photograph of a wound or X-ray to a colleague for a second

opinion [9]. A DeepMind Health report in 2017 stated that doctors are using Snapchat to send patient scans to each other and that clinicians use camera apps to record particular details of patient information in a convenient format on their tablets and smartphones [10, 11]. The authors described this practice as "clearly an insecure, risky, and non-auditable way of operating, which cannot continue" [10, 11]. The main reason for the insecurity of sharing data via mobile devices is the fact that most of these devices are used for both professional and private use, and thus often connected to mobile networks or public Wi-Fi hotspots instead of secured wireless networks. Furthermore, when data or pictures of patients and radiology image are made with a private device, the information is usually stored on that device's hard drive or in a non-secured server, which does not comply with the GDPR legislation.

In a recent study it was shown that 72% of doctors has a desire for a secure messaging app to allow transmission of patient-related information to colleagues in a secure way [9]. The ESR paper on the proper use of mobile devices for radiology purposes states however that mobile devices are currently not recommended as tools for primary interpretation of radiological studies and that the use of mobile devices for image and data transmission carries risks that should be considered, especially regarding confidentiality [12].

In another recent survey, radiologists expressed concerns about the existing legislation, guidelines, and policies for using SoMe in health care (75%), the risk for privacy of the patients (39%), the risk of privacy of radiologists (39%), and the insufficient knowledge about social media among radiologists (37%) [13].

It is important to consider that personal identification information can be stored on a mobile device that these devices can be lost or stolen, and that messages can easily be viewed by unauthorized users, e.g., with an unsecured device, or when messages are displayed on the screen before the login screen is opened. So, when SoMe is used, informed consent of the patient is needed, and anonymization might be required. The American College of Radiology states that "It's the responsibility of the radiologist to securely and

effectively utilize mobile technology in the best interests of patient care." [14].

Nowadays however dedicated apps and cloud services that are specifically designed and implemented for medical doctors have been introduced in the SoMe domain, such as Siilo. These apps are restricted in access and have high levels of security by using a variety of methods to protect the patient data. All users have to be identified as medical professional before access is allowed. The images or videos made with the mobile device are stored in a sand-box type of isolated archive on the hard disk, and all information is automatically removed within 30 days. These apps also have functions to make patients unrecognizable and to wipe out sensitive patient information. To be used with sensitive medical imaging data, such solutions need to be 100% compliant with General Data Protection Regulation (GDPR), have end-to-end encryption, authentication service for access on the app, no local storage of data (unless sand-boxed) and functions for proper anonymization of images and texts.

6.6 Conclusion

Current health care requires the ability to share imaging data within institutions, between institutions, and with patients. When sharing imaging data, the most crucial point is to adhere to the existing standards (IHE, DICOM, FHIR, etc.). If no standards exist however, one should put in ample effort to implement it as secure and safe as possible and prepare to shift toward a standards-based solution as soon as they are available. Integration and interoperability of systems is essential in order to avoid a multitude of interfaces and software packages.

With respect to safety, security, and privacy of patient data, it is important to only provide the relevant information to each specific user, to ensure de-identification capabilities, and to build systems that by design are based on privacy.

Transmission of data through common social media and messaging apps is currently not secure enough. The data might contain highly sensitive and confidential information. Secured and

GDPR-compliant applications for health-care purposes are nowadays available however, and thus should always be used whenever sensitive patient data are shared.

Whether data is shared within the institution, with other institutions or with patients, the key is to support the "customer" and to provide him/her with the right information at the right time while complying to the rules and regulations.

As shown above there are many methods to share imaging data, with preference depending on location. It can be difficult to pick one specific method to solve all imaging data sharing demands, therefore the most favorable is a mixed solution [8].

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