Telemedicine – Applications in Radiology

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Introduction:

The branch of Radiology has started a century ago following the discovery of X-Rays by Roentgen in 1895. There was tremendous development of this branch in the subsequent 50 years with the addition of contrast agents, exploration to different areas / organs in the body providing non invasive diagnostic information. Addition of newer image based sectional imaging tools expanded the horizon of Radiology boundlessly. This includes ultrasound and Doppler studies, CT Cross sectional imaging, MR imaging, Nuclear Medicine and Digital subtraction imaging. There was a parallel development of computers which permitted these development at a tremendous speed. The information available in all these imaging modalities were displayed on a CRT, and stored as hard copies in the form of photographic film with patient or in the hospital itself through massive film libraries. Maintenance / retrieval and storage of these information was a Herculean task. This had often resulted in loss of vital data due to loss of the film itself (either by completion of the shelf life or loss of film) or misplacement of film. Retrieval of the information was time consuming and often unsuccessful.

Picture Archival and Communication System (PACS) – Teleradiology:

With the development of technology, the film based imaging has given way to digital information which could be stored in a computer disk, CD or DVD. The concept of digital data transfer from one modality to another and storage in a main computer (workstation) and distribution of these images to different sections of the department for proper manipulation and image diagnosis and later available for archival. The images are available either online or offline or on CD/DVD/Juke boxes. Different manufacturers have their own softwares, hence integration of these information tends to be difficult. With the availability of DICOM–ACR NEMA 3 Standard, the communication between modalities become easier.

The availability of CR/DR permitted the electronic transfer of data from plain film

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examination. Non DICOM complaint equipment were brought to DICOM complaint system through PACS broker. Availability of RIS (Radiology Information System) helped to integrate the patient profile on a single area and to create a DICOM modality work list which further reduced the work load. The addition of hospital information along with PACS permitted integration of all information in a single unified area which are available in the system online or offline. The online data are typically available for 6 months and offline in DVD juke box for indefinite period. The storage in SAN System make it possible to get these information online for several years. Subsequently offline data are available in DVD juke boxes.

Diagnostic Aspects and Issues in Radiology

A) Nuclear Medicine, Ultrasound, Echocardiogram, CT and MRI

Currently available pictures in Nuclear Medicine are of low resolution, hence transmission and storage are of not much problem. Typically Nuclear Medicine pictures are of 128 x 128 pixels and 7 to 8 bit gray scale resolution. The MR and CT images ranges from 512 x 512 and 8 to 9 bit resolution. These images can also be stored easily in the PACS server. It is important in the Radiology department that the images are stored in DICOM format without any loss of information. The diagnostic workstation where the radiologists report should have high resolution display monitors. A minimum of 2K monitors are ideal. Once the reporting is over the images can be stored in loss less compression format in the server or in the web server for the entire hospital network. A typical compression format should be 3:1. Anything above this can give rise to loss of information, hence misinterpretation resulting in false positive or false negative diagnosis.

B) Plain X-Rays

The highest resolution images are Plain X-Ray images with 4096 x 4096 spatial resolution and 12bit gray scale. This means large volume of data. Compression of these data would give rise to loss of information. Hence care should be taken not to loose any information on these images.

C) DSA or Cine Angio pictures

The resolution of cine angio pictures are also comparable to CT. But each study contains large volume of data, which also have to be stored in the form of movie files. Whereas the digital subtraction angiogram are extremely high resolution images, which requires large space of storage.

D) Applications in Cardiology

The Cardiological diagnostic images consists of Echocardiogram and cine angio data. It

is vital to have all the information failing which misinterpretation can occur.

E) Applications in Neurology

The neurological images are predominantly CT scan, MRI films and DSA films. DICOM storage is a must in all these modalities, failure of adherence of DICOM compliance can give rise to misinterpretation.

F) Application in Orthopedics

Orthopedics films consists of predominantly Plain X-Rays. Plain X-Rays resolution are the highest, hence this also has to be stored without loss. Cases have been reported in the literature where hairline fractures were missed on storing in digital format of low resolution. The same is to on chest X-Rays, hence care should be taken in pulmonary chest films.

G) Applications with Telemedicine

Teleradiology with Telemedicine link is an ideal combination, where the patients, patients doctors can by themselves interact each other, the concerned clinical problem. The noninvasive images generated by the scanners give a better idea about the patient condition. Hence if both of them are combined a lot of information could be brought about. One should aim for this ideal set up, which will generate the best advantages of Telemedicine and teleradiology

H) Remote center issues

It is true that the films are transferred electronically from remote center to main center, lot of tangible and intangible benefits could occur to the patients, family, society, hospital etc (Table 1). However digitization by ordinary scanners, storing and transmitting images in jpeg format can result in low resolution, loss of data and image manipulation possibilities. This can lead on to wrong interpretation of images, wrong side of operations and even improper management. Hence it is a must that proper DICOM compatible hardware should be available at the remote center. In the same the receiving station also should be equipped with adequate hardware to depict the images without loss of resolution (Fig 1).

I) Plain X-Rays with the patients

Another area of integration in Radiology is the stray film coming to the department which can be available again in the network through DICOM scanners.

Once the data is integrated in the workstation after the necessary requisites such as manipulation, interpretation and reporting the same may be transferred to Web Server where it is available for the entire hospital to view.

An extension of PACS is teleradiology with viewing of images in the different sections within the hospital, receiving of images for interpretation from a remote area through

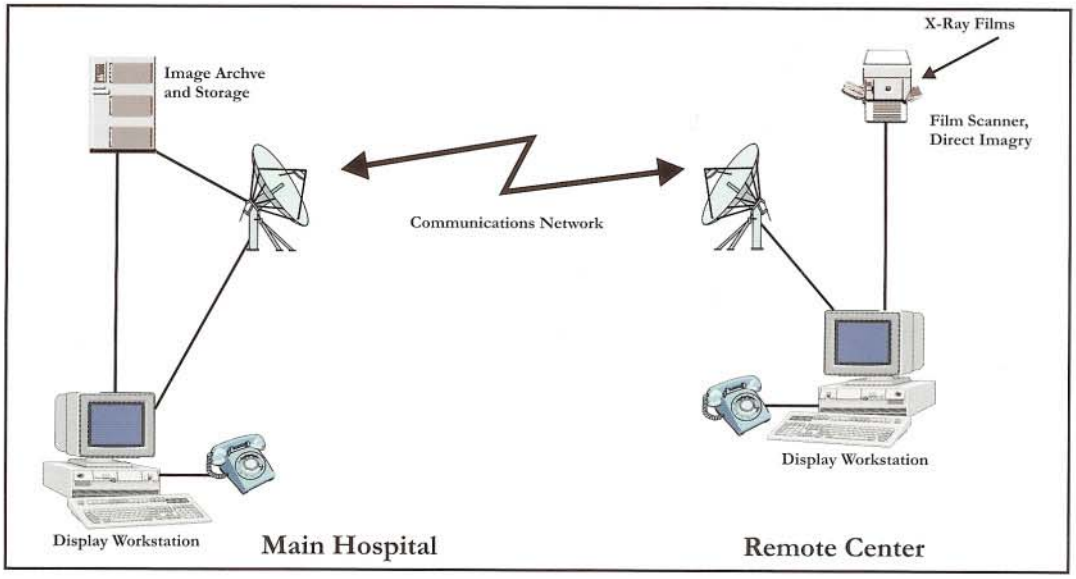

Figure 1: Teleradiology Link between Main Hospital and Remote Centers

ISDN lines/ fibroopitc cable / Microwave Network through a Telemedicine link, or viewing of the images in the residence itself for emergency purposes (Fig 2).

Applications and Advantages of Tele-Radiology:

Picture archival and communication system in Radiology have profound influence on image management and has resulted in the following advantages.

1. Archival / Retrieval of all image information concerned with the patient in a single folder in a unified area that resulted in
   a) Reduction film cost
   b) Reduction man power
   c) Reduction reexamination
   d) Reduction film loss
   e) Retreivability of images at any point in time
   f) Images do not degrade with time
   g) Inter departmental discussions
   h) Inter institutional discussion
   i) Inter continental discussion
   j) Storing of clinically relevant academic images as teaching file
   k) Retreivability of images at any point within the hospital, residence or outside the working place
   l) Transmission of images to elsewhere for second opinion
   m) Receipt of images from any remote areas for getting expert advice

This has resulted in the following tangible and intangible benefit to the patient and family, medical personnel, hospitals / teleradiology personnels and society .

Table 1: Tangible and Intangible benefits of Teleradiology

Recipients	Tangible benefits	Intangible benefits
Patients and families	• Reduced costs of travel and accommodation • Reduced costs where teleradiology prevents surgery/other medical procedures • Reduced need for childcare when travelling • Reduced time off from work	• Faster management of medical problems • Reduced anxiety where second opinion is rapidly provided and, on occasions, surgery or other procedures are avoided • Equitable access to specialist level opinion • If patient transfer is necessary, can be fully coordinated and planned beforehand • Future management at the primary site can be facilitated
Medical providers	• Reduced time and cost of travelling • Better management of patients • Cash flow to rural centres due to retention of patients • Increased competency of interpreting radiologist (due to large case load, exposure to more rare conditions)	• Increased exposure to expertise for rural staff • Staff retention in rural areas by improved peer and specialist support • Increased satisfaction that management at the primary centre is appropriate following rapid expert advice • Enables tertiary site to develop a more organised approach to second opinion referrals
Hospital providers & Teleradiology providers	• Wider delivery of services - increased revenue • Decrease in unnecessary patient transfer • Reduced need for clerical attendant staff • Reduced costs of film	• Remote pre-admission - increased efficiency • Reduced length of stay • Improved care and health outcomes • Facilitates recruitment of medical staff for more remote areas
Society	• Less time off from work - improved productivity • Decreased burden of illness on society	• Great equity in quality, efficiency and access to medical care • Reduced morbidity and mortality • Aids appropriate allocation of overall health resources • Less social disruption as continuity of care is facilitated locally

Disadvantages:

1. Cost of the equipment and installation are pretty high
2. Security of data and privacy of data

Important aspects of diagnosis from various modalities in Radiology

Q. What are the Ailments or defects that can be diagnosed from the modalities like Nuclear medicine, Ultrasound, Echo, CT, MRI, Plain X-rays, Cine Angio pictures or DSA?

A. Currently without medical imaging no structural diseases can be diagnosed. It is even invading into metabolic and functional disorders. The fact is there are limitations in each modality of imaging .

1. Plain X-Rays-gives only two dimensional images, which is very good for detecting bone and joint problems like fractures, etc. whereas it doesn't give adequate information about soft tissue details. Certain metabolic disorders that affect on the skeletal system can also be diagnosed by plain X-Rays. Because we are using X-Rays for imaging X-Ray exposure to the patient is a major draw back.
2. Ultrasound & ECHO-It's very good for pregnant women, foetus and neonatal imaging. And it is the imaging modality of choice in these group of patients. All decisions on obstetrics and gyanaecology are done through this imaging. However it is not good for bone imaging, air containing structures. Doppler also give a base line idea about the vascular and heart problems.
3. CT: This is a very good tool for brain, body including heart and vessels imaging. 3D Imaging is possible with this. With the availability of multi slice CT scanners, it is possible to see the entire body in 20 seconds. But again it is an X-Ray based modality, hence the disadvantages of X-Rays.
4. MRI: Vey good for brain and spine imaging. It can even detect vascular problems, metabolic and functional problems. No ionizing radiation is used. It's expanding into receptor imaging.
5. Nuclear Medicine food for functional imaging.
6. DSA and Cine Angio: Exclusively used for diagnosis and treatment of heart and blood vessel related problems. For eg. coronary angioplasty for coronary artery block, aneurysm coiling for brain aneurysms.

   Often a combination of different imaging modalities may be required to assess the patient status. There the doctor has to decide which is the ideal imaging algorithm.

Q. What are the ailments or disease that can be diagnosed totally through Telemedicine and limitations if any?

A. If suitable images or imaging equipments are available at the remote center all images can be transmitted to a specialist center and can make suitable diagnosis. You may be aware that in Bangalore a set of doctors are completely practising Telemedicine and reporting films from MR, CT, US, etc. from United States. Major limitation is you cannot directly talk to the patients or examine the patient. That also to a great extent is solved by linking the medical images with the Telemedicine facility. Again if the images can be transmitted as DICOM loss less compression, it is as good as seeing the image from the station it is generated.

Q. What are the ailments which should not be diagnosed through Telemedicine at all, if any?

A. Any diseases which requires clinical examination of the patient cannot be diagnosed by Telemedicine. For eg. skin disorders, psychiatric disorders etc.

Q. Finally any caution/advise to GPs on the usage of Telemedicine in handling and studying the radiological images for the respective diagnosis?

A. Most important thing is images should not be manipulated ans should be send in the same resolution as it is ought to be from the remote center. The main center doctors should understand what are the machine capabilities and should advice them accordingly taking into consideration of the equipments and resolution capabilities.

Conclusion:

Currently medical images can be stored in an archival server in DICOM format from any modality whether it is DICOM or Non DICOM. Once this is done the images can be stored in compressed or non compressed format in the web server, which is available for communication to the entire hospital, outside the hospital, residence, or other countries. Simultaneous Telemedicine link help in easy interaction of clinical data with the imaging data from experts from remote corner. This can help in solving difficult clinical problem instantaneously. However we have to adher to the DICOM–ACR–NEMA–3 Standard failing which the disadvantage can overtake the advantage of this wonderful technology. Hence we have to address the following issues also.

1. Protection against loss
2. Protection against alteration
3. Privacy and confidentiality requirements
4. Patient identification number require stronger protection

References:

1. Alvarez, D.,. Cost justification of PACS. *Telemedicine Today, October 1998,* 13,16
2. Bergmo, T.S., An economic analysis of teleradiology versus a visiting radiologist service, *Journal of Telemedicine and Telecare.* 1996, Volume 2, No.3, pp. 136-142.

3. Bolte, R., Lehmann, K.J., Walz, M., Busch, C., Schinkmann, M., & Georgi, M, An economic analysis of the new teleradiology system, KAMEDIN. *Journal of Telemedicine and Telecare,1998, 4 (Supp. 1),* 108.
4. Davis, C.D. Teleradiology in rural imaging centres. *Journal of Telemedicine and Telecare.* 1997 Volume 3, pp. 146-153.
5. Department of Finance, *Doing Evaluations. A Practical Guide.* 1994, Commonwealth of Australia, Canberra
6. Duerinckx, A.J., Kenagy, J.J., & Grant, E.G.. Planning and cost analysis of digital radiography services for a network of hospitals (the Veterans Integrated Service Network). *Journal of Telemedicine and Telecare*, 1998, 4, 172-178.
7. Halvorsen, P.A. and Kristiansen, I.S. Radiology services for remote communities: cost minimisation study of telemedicine. *BMJ.* Volume 312; 25 May 1996. pp.1333-1336.
8. Hayward, T. & Mitchell, J., Renal Case Conferencing using Teleradiology and Videoconferencing between Adelaide and Alice Springs, *Journal of Telemedicine and Telecare, 1999, 5: 205-207*
9. Hayward, T., Mitchell, J., Bullock, D., Carine, F., Boundy, C., *Report on the South Australian Radiology Network Project.* Women's and Children's Hospital, North Adelaide, 1999
10. McDonald, I., Hill, S., Daly, J., & Crowe, B., *Evaluating Telemedicine in Victoria: A Generic Framework.* Victorian Government Department of Human Services: Melbourne, 1998
11. Stoeger,A., Strohmayr., Giacomuzzi, S.M., Dessi, A., Buchberger, W. and Jaschke, W. A cost analysis of an emergency computerized tomography teleradiology system. *Journal of Telemedicine and Telecare.* 1997, Volume 3, pp. 35-39.
12. Tilke, B. Teleradiology services grapple with costs: Affordable low-end systems are gaining in popularity. *Telemedicine and Telehealth Networks.* August 1997, pp.17-20.