Teleradiology its Application, Transmission, Legal Issues and Market in Veterinary Medicine: A Review

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ABSTRACT

Teleradiology is the practice of transmitting the different radiological reports generated via X-rays, CT-scan and MRI from one part of the world to the another or one location to the other to get the consultation and interpretation from the different expert radiologists. In Veterinary, it was first commercially available in the early 90s. Previously it was poorly developed due to the limited internet speed and lack of essential software but currently, the practice of teleradiology in Veterinary Medicine has become universal due to proper broadband connection, availability of image compression, PACS and DICOM software. This review aims to summarize the goals, applications, transmission, method of image acquisition and digitalization, types of teleradiology, its legal issues and market in Veterinary Medicine.

Key words: DICOM, PACS, Teleradiology, Veterinary medicine.

Telemedicine is a broad term including all the methods in which doctor and patient interaction are not on the same location and a type of telecommunication method is used. It is also called telehealth, online health, or e-health. Teleradiology is a branch emerged from telemedicine in which radiological images are used to transmit from one location to another via telecommunication. It is the point-to-point communication of radiographic images with the motive of achieving an interpretation (Jarvis and Stanberry, 2005). It was first developed for military patients. The field units used to send radiology images to the expert radiologists for diagnosis. In the eighties, teleradiology came with a camera system which was not so helpful in diagnosis. In the mid-eighties, the first generations of PACS (picture archiving and communication system) came in the medical field for clinical evaluation (Barneveld Binkhuysen and Ranschaert, 2011). The first commercial available teleradiology system in the veterinary field was introduced by professional software Inc. (PSI) of Effingham, IL in 1994. In this system image in JPEG format transmitted from a veterinary polyclinic to a veterinary radiologist via modem technology but this method comes out to be a failure because it can process only one case at a time and usually time consumption is more. The increased development and deployment of digital imaging systems and the quickly increasing availability of high bandwidths allowing transmission of large data volumes at high speed have dramatically widened the scope of teleradiology (Barneveld Binkhuysen and Ranschaert, 2011). Teleradiology has been subjected of several health technology assessments in different countries concerning the context of use (Takada et al., 2003; Krupinski et al., 2003; Larson et al., 2005; Barneveld Binkhuysen et al., 1995). Teleradiology is rapidly becoming established as a standard in patient care, providing rapid access to image interpretation by a consulting radiologist (Essman, 2011). Teleradiology is an advancement in Human and Veterinary Medicine and widely used now a days.

EARLY TELERADIOLOGY

It is also known as indirect teleradiology. Under this, services are provided by large companies contracted with different radiologists as an autonomous contractor. These large companies are known as middle man, communicate with veterinarians who send the radiological images to the companies via email or electronic channels. The companies send these images to the contracted radiologists. The radiologist will assess these images and after interpretation, they send an official report via middle man company.

MODERN TELERADIOLOGY

This is a direct and non-proprietary method of image interpretation by a radiologist of choice. Direct teleradiology utilizes an open standard of communication called DICOM. Direct teleradiology allows the veterinary clinics to access to the internet to send their images directly to a veterinary radiologist of their choice without the aid of any middleman companies. In this method, a veterinarian practitioner develops a professional relationship with a veterinary...
radiologist who they think is valuable for them. This is the method overall to decrease the cost of image interpretation.

GOALS OF TELERADIOLOGY
Concerning the goals of teleradiology, its primary goal is providing timely consultation and interpretation of radiological queries. In some emergencies, on-call radiological interpretation is also facilitated. The interpreted images can be saved for the educational purpose as well as reference images. Teleradiology improves the quality of knowledge about radiology and acts as a supporting branch for telemedicine.

APPLICATIONS OF TELERADIOLOGY
1. Primary interpretations
   I. Images directly sent to radiologists
   II. Images indirectly sent to radiologists via middle man companies
2. On-Call coverage
3. Second opinion consultations from large hospitals
4. Image storage and archival by companies and institutes

The first application of teleradiology is the primary interpretation of the images done by two methods, either image directly sent to the radiologists or indirectly sent to the radiologists via middle man companies or software. Direct and indirect methods have been already described in this review. The second application is the on-call coverage to instantly get the interpretation of images in emergencies. The Second opinion consultations usually come from large scale hospitals having all of their radiological images reviewed by a highly-certified veterinary radiologist. Teleradiology act as an expansion of their practice with direct communication to a veterinary radiologist for second opinions (Poteet, 2008). Some companies and institutes are having image archive access for the user with digital systems. These off-site Image archival facilities store these images in a searchable, query and retrieve database, typically using the DICOM 3.0 standard (Bushberg et al., 2001; Dreyer et al., 2006).

IMAGE ACQUISITION AND DIGITALIZATION
Any type of radiological images which are in digital format can be transmitted via teleradiology. Most of the imaging techniques provide digital images directly like ultrasound, CT scan and MRI. These images must be converted into a DICOM format before transmitting via PACS system. DICOM is very essential because it gives direct communication between a veterinarian and the expert radiologists. Even these radiological images can be converted into other formats but due to medicolegal issues non DICOM images are not allowed (Wright et al., 2008). Image compression is also an important step in teleradiology and the original image files size are too big for transmission. So compression of these images makes them possible for easy transmission by at the expense of image quality (Erickson, 2002).

DICOM (DIGITAL IMAGING AND COMMUNICATIONS IN MEDICINE) AND ITS APPLICATION
DICOM is the standard for the communications and management of medical imaging information and related data. DICOM is most commonly used for storing and transmitting medical images enabling the integration of medical imaging devices such as -scanners, servers, workstations, printers and PACS that may have been installed by multiple manufacturers (Indrajit, 2007). DICOM gives standards for different imaging techniques such as radiography, ultrasonography, CT scan, MRI and radiation therapy. DICOM incorporate the protocols for image exchange, compression and presentation and 3-D visualization (Kahn et al., 2007). DICOM file or DICOM format file is represented by “dcm”. A DICOM file is having two components a header and an image data included in a single file. The first information in a DICOM image is in the form of a header which constitutes the information about the patient (Name, Birthdate and ID number) and the modality (device parameter, Calibration, X-ray and Contrast media). After the header image intensity pixel data stored in the form of a series of 0s and 1s. It may contain the information about a single image or multiple studies depends on the modality used (Varma, 2012). Images sent directly via DICOM systems can be completely manipulated (windowing, leveling, etc.) while such abilities are restricted on digitized images attained with a laser or digital camera (Pottet, 2008).

PACS (PICTURE ARCHIVING AND COMMUNICATION SYSTEM)
PACS is a medical imaging technique that provides cost-effective storage and easy access to images from multiple modalities (Choplin, 1992). Radiological images are transmitted digitally via PACS eliminates the requirement of manual file transfer, transport the file with the film jacket or protect the X-ray film in folders. Images taken from different modalities converted into DICOM format and transferred via PACS.

Components of PACS:
- Imaging modalities- X-ray, CT, MRI
- A secured network for the transmission of information
- A Workstation to receive and interpretation of the data
- Archives for the storage and retrieval of images and reports

IMAGE COMPRESSION
Most of the radiological images are very large files. It is not possible to send these files via broadband connection because of much time consumption. So, image compression is typically required even after a good broadband connection. The image compression should be done up to a limit because high compression can deteriorate the image quality. Most of the traders prefer the compression in JPEG format because these files can be easily sent as email attachments. If a medical image has been compressed into a JPEG image, the different quality of the image can not be digitally altered. So, JPEG compression is not recommended in teleradiology.
So, DICOM is necessary for teleradiology because it provides direct compression (vendor-independent compression) of medical images.

**DICOM TRANSMISSION OF IMAGES**

DICOM image transmission is based on the concept of direct teleradiology which eliminates the role of the middleman. To accomplish the DICOM image transmission there is a need for a DICOM software supporting system. In this system, the radiologist needs to provide application entity title, port number and IP address. These information are editable and can be entered into the sending computer software. Customer lock-in concept can be completely avoided by DICOM transmission of images. A customer lock-in or vendor lock-in is a concept of economics in which a customer will completely depend on a vendor for product and services. The vendor will act as a middleman and you can only able to send those images which the company allows you to send. So DICOM transmission is having an advantage over vendor lock-in concept in teleradiology (Poteet, 2008).

**LEGAL ISSUES IN VETERINARY TELERADIOLOGY**

Veterinary teleradiology is having the following legal issues:

**State veterinary license**

State-wise veterinary license is necessary for the veterinarian to give consultation. But in teleradiology, many radiologists are giving the interpretation of the medical images comes from the other states. So a state-wise license should be provided by the state authorities.

**Liability insurance coverage**

A veterinarian radiologist who is providing his services to the clients of other states make sure that their liability insurance is valid to those states in which their business is established.

**Client–patient–veterinary relationship**

A Client–patient–veterinary relationship is not obtained in case of teleradiology because the radiologist is giving the interpretation of the images referred by the veterinarian and the teleradiologist is paid by the referring veterinarian for their services.

**VETERINARY TELERADIOLOGY MARKET**

Veterinary teleradiology market is growing at a remarkable compound annual growth rate due to shortage of skilled radiologists in the underdeveloped countries. Several companies are research and development to get new and more advanced imaging technologies, which helps to boost the veterinary teleradiology market. Increase in the livestock population, animal diseases and the number of veterinarians is expected to fuel the veterinary teleradiology market. However, the high cost of teleradiology, the dearth of skilled radiologists and unawareness about veterinary teleradiology in developing and underdeveloped countries may restrict the growth of veterinary teleradiology market.

**SEGMENTATION OF VETERINARY TELERADIOLOGY MARKET**

It can be classified based on the type of modality, service, animal and type of end-users.

1. Based on the type of modality used:
   - CT-scan
   - Ultrasound
   - X-ray
   - MRI
2. Based on the type of service:
   - Day time coverage
   - Emergency services
   - Second opinion
3. Based on the type of animal
   - Companion animals
   - Livestock
4. Based on the type of end-user
   - Veterinary hospitals
   - Private clinics
   - Radiology centres

**TELERADIOLOGY IN INDIA**

The first use of teleradiology was done by a private imaging center of Mumbai in 1996. The first official public demonstration of teleradiology was given by Siemens at the annual Congress of IRIA (Indian Radiology and Imaging Association) in 1997 (Burute et al., 2009). Teleradiology Solutions was the first company established in India in 2002. Teleradiology is not so popular in Veterinary Medicine in India. Cost and internet facilities are among the two most important reasons for its limited application. The other reason is the shortage of highly skilled radiologists. Even the facilities of different advanced imaging modalities are very limited in Veterinary institutions. A very limited number of expert veterinary radiologists exist at different places in the country. So these are the reasons why the growth of teleradiology is essential for all the veterinary institutions and polyclinics in our country. Although Telerad Tech company is providing a PACS system known as VETspa.
which provide a workflow for Veterinary Radiology in India. But we are still running behind of other countries so a lot of improvement in the field of veterinary radiology is required.

**CONCLUSION**

Teleradiology is a rapidly emerging technology in Veterinary Medicine. It is the combination of computer technology and medical science. Teleradiology improves patient care as it allows a specialist to serve without being present at the location of the patient. An x-ray image taken in London may be interpreted by a radiologist in Los Angeles or a CT-scan of a dog present in Mumbai can be read within an hour by a specialist in Paris. So it is really helpful for animal care as an emergency case can be easily solved in less time. In the new era of digitalization, X-ray, CT-scans and MRI of veterinary patients can be interpreted by a skilled radiologist at any location by the click of a button. It is still underdeveloped in Veterinary Medicine in India. But, as technology is improving and the cost of technology is decreasing, teleradiology will become a routine concept in Veterinary Radiology.

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