European Journal of Radiology 78 (2011) 205–209

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Teleradiology: Evolution and concepts

F.H. Barneveld Binkhuysen[a,*], E.R. Ranschaert[b,1]

[a] Soester Hoogt 4, 3768MK Soest, Netherlands
[b] Department of Radiology, Jeroen Bosch Ziekenhuis, Postbus 90153, 5200 ME's-Hertogenbosch, Netherlands

ARTICLE INFO

Article history:
Received 10 August 2010
Accepted 13 August 2010

Keywords:
Teleradiology
Clinical governance
Medico-legal
Quality assessment

ABSTRACT

Teleradiology has become a reality for several years now, but its existence still has not been freed from all controversies. From the beginning the military has been the driving force for teleradiology. Today teleradiology has many purposes worldwide ranging from services for expert or second opinions to international commercial diagnostic reading services. Ten years ago image quality, transmission speed and image compression were important issues of debate. Today the focus is on clinical governance, medico-legal issues and quality assessment. The increasing use of teleradiology reflects the changing world of clinical practice, service delivery and technology.

1. Introduction

Teleradiology is often defined as the electronic transmission of radiographic images from one geographical location to another for the purposes of interpretation and consultation. 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 this medium. Teleradiology has been subject of a number of health technology assessments in different countries with regard to the context of use [1–4]. Advantages and disadvantages have been described extensively. Nevertheless other important aspects of teleradiology such as clinical governance, medico-legal issues and quality assessment, have not yet been studied in great depth. Looking in the future the distinction between PACS and teleradiology will be blurred and virtual organisations with distributed capabilities can become reality. In this article we will describe the ongoing debate about teleradiology.

2. The beginning

Teleradiology was first developed for military purposes. Field units could sent radiology images to hospitals at the home country for diagnosis and further patient management. The first commercial teleradiology systems in the eighties worked with camera systems or video-grabbed selected hardcopies for subsequent digitized image transfer. An improvement was the introduction of the laser digitizer, which also had the disadvantage of being able to handle only one image at a time. In the mid-eighties the first generations of PACS were installed in the medical environment for clinical evaluation. It soon became clear that the change from analogue to digital processing of medical images could change the workflow dramatically [5]. Teleradiology had become a reality, but it took another ten years before the relatively low performance and high costs of the computer systems available at that time would develop into feasible applications. Besides the lack of affordable image handling systems the high cost of data transmission was also a serious hurdle hindering a more widespread implementation of teleradiology. However during the last decennium most technical limitations have resolved thanks to the widespread introduction of digitization processes in radiology practices and the low cost of Internet communication [6]. In the early days, when the analogue–digital conversion of video signals was being used for capture of cross-sectional images, the preservation of image quality was an important issue. To improve transmission speed several data compression techniques were used and analysed. These remained controversial until the arrival of more advanced techniques such as wavelet-compression, allowing the transmission of good quality images at reasonable speed. Until some years ago those issues like image quality, transmission speed and compression techniques were subject of intensive debate. Nowadays attention is more directed towards issues such as clinical governance, medico-legal and quality assessment.

3. Clinical environment

There is a wide variety of settings in which teleradiology can be used [6,7]:

* Corresponding author. Tel.: +31 6 53864771.
E-mail addresses: fbb@imatel.nl (F.H. Barneveld Binkhuysen), e.ranschaert@jbz.nl (E.R. Ranschaert).
[1] Tel.: +31 497 476688.

0720-048X/$ – see front matter © 2010 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ejrad.2010.08.027

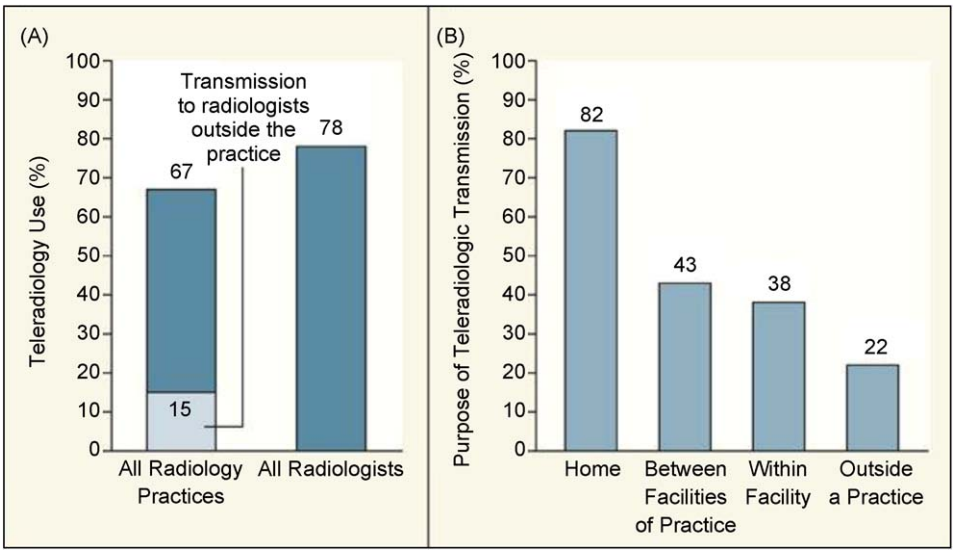

Fig. 1. Prevalence of teleradiology use in the United States in 2003 and the purposes for which teleradiologic transmission was used. Data are from Ebbert et al. [13].

- A well known example of the use of teleradiology is obtaining expert or second opinions. In Tirol in Austria a teleneuroradiology-network was created between three rural hospitals and a university hospital for triage of acute neuropatients. Between October 2007 and March 2008 there were 744 teleradiology patients. The observed teleneuroradiology-network guarantees Tyrolean healthcare-providers to diagnose and treat patients with acute neurological symptoms in a time period off less than 60 min [8].
- From the beginning the military has been a great promoter and driving force of teleradiology. During the Balkan war in the mid-nineties a deployable teleradiology system was installed. From 1995 to 1997 more than 20.000 digital diagnostic examinations were acquired, transferred and archived using this system [9].
- Teleradiology can also play a significant role in humanitarian and disaster-relief operations, e.g. during the 212th MASH medical treatment of casualties following a large earthquake in the Kashmir region of Pakistan in 2005 [10].

Likewise, as there is a wide variety in applications for teleradiology, many different service and business models exist, for example: after hours 24/7 coverage, radiology services in remote areas, and subspecialty readings or expert readings, e.g. cardiac imaging and virtual colonoscopy.

Reasons to make use of teleradiology services can be a growing or changing workload, a structural or temporary shortage of radiologists, and a shortage of expertise. In some situations teleradiology is also used for educational purposes.

Teleradiology in its 'purest' form is simply transmitting images from one location to another. This can be limited to intra-mural applications in a given situation:

- teleradiology 'integrated' in a hospital with or without different locations,
- point-to-point (hospital to radiologist's home),
- regional hospital networks (e.g. Scandinavia and Spain) [11].

When used for extra-mural applications, images are transmitted to:

- an accredited (international) teleradiology reading centre [12], possibly even in a different time zone, e.g. 'Nighthawk services',
- to radiological experts for specialised reading services, not available in the hospital (e.g. virtual colonoscopy),
- another hospital, academic (tertiary) centre or diagnostic centre (for second opinion),
- an expert centre for training purposes, giving support during the start up phase of a new technique (e.g. virtual colonoscopy).

In the United States almost 70% of all radiology practices reported using teleradiology [13]. In 2003 primarily academic practices were less likely to use teleradiology than private radiology practices. According this study, the most common purpose of teleradiology is to transmit images to radiologists at home; about a quarter of the users sent images to outside radiologists (Fig. 1). A significant increase of teleradiology was seen in the prevalence of PACS. Although no published data are available, it is likely that in Europe the increasing availability of PACS in hospitals has similarly led to the possibility to transmit images to the radiologists' homes, to easy the burden of being on-call. In the Netherlands a number of academic centres are also using teleradiology because of staff shortages. Several commercial teleradiology companies are currently active within the EU, but the presence of different healthcare and legal systems in the EU member states make the situation much more complex than in the US.

These extra-mural applications can be very complex, because often integration of different information systems is required. Not only the PACS systems of different locations have to communicate, but also the information coming from the different RIS and HIS systems has to be integrated [14]. Also aspects such as confidentiality and data integrity have to be taken into account.

4. Commercial international teleradiology

In the future there will be no distinction between PACS and teleradiology. Virtual imaging organisations (or expert reading centres) will become reality [15]. The following question arises: Will teleradiology profoundly change the way we practice our profession?

Can radiology services almost completely be outsourced when we keep in mind that less than 10% of the total radiology production, namely vascular and interventional radiology, is exempt from outsourcing? Theoretically yes, but more likely no. Radiologists have many other tasks besides reporting images such as: justification of request, ad hoc problem solving, optimising and tailoring individual