Multi-media messaging, MMS,
multiple injury imaging, musculoskeletal injuries,
trauma, mobile teleradiology, PDA phone,
Computed Tomography, mobile devices, Telemedicine

Artur WOJCIECHOWSKI[*,****], Wojciech GLINKOWSKI [**,***,****],
Marek GOŁĘBIOWSKI[*], Andrzej GÓRECKI[**]

THE USE OF MULTI-MEDIA MESSAGING AS SUPPLEMENT INFORMATION OF MUSCULOSKELETAL INJURY CASES

Orthopedic trauma and emergency medicine practice often require images have to be reviewed and reported on from locations outside the department. Image evaluation by radiologists and orthopedic trauma team is crucial for decision making. In difficult cases various specialist will be involved. A quick reporting system and efficient access to radiology information are essential. New developments in IT technologies have recently emerged to bridge the traditional gap between imaging and reporting and consultation processes. Physicians involved in treatment of injured patients require rapid access to images. When departments like Medical Imaging or Radiology and Emergency and/or Orthopedic Trauma are located separately in relatively distant location within Clinical campus the data sharing is necessary. If the facility does not have implemented PACS system jet informatic technology bypass should be considered. Most of the hospitals without integrated informatics network are covered with GSM network. Advanced telecommunications technology as higher resolution PDA phones handsets with multi-media messaging (MMS) service capability may enhance simple store and forward telemedicine system for transfer of the medical images and to support accurate management decisions. Our study confirmed that PDA phones equipped with digital cameras for image and video capture can be used as an efficient tool facilitating rapid diagnosis in multiply injured patients. MMS images with limited size files may supplement clinical decision. Images sent via MMS are not always fully diagnostic but usually sufficiently informative to manage the patient.

1. THE USE OF MULTI-MEDIA MESSAGING AS SUPPLEMENT INFORMATION OF MUSCULOSKELETAL INJURY CASES

1.1. INTRODUCTION

Orthopedic trauma and emergency medicine practice often require images have to be reviewed and reported on from locations outside the department. Image evaluation by radiologists and orthopedic trauma team is crucial for decision making. Images should be well prepared and delivered. The procedure consumes more time if no

[*] Department of Clinical Radiology, Medicial University of Warsaw, 02-004 Chałubińskiego 5, Poland

[**] Chair and Department of Orthopedics and Traumatology of the Locomotor System, Center of Excellence "TeleOrto", Medical Univeristy of Warsaw, 02-005 Lindleya 4, Poland

[***] Department of Anatomy, Center of Biostructure, Medical University of Warsaw

[****] Polish Telemedicine Society

PACS/RIS/HIS is available. Some facilities do not have implemented PACS systems jet. When departments like Medical Imaging or Radiology and Emergency and/or Orthopedic Trauma are located separately in relatively distant location within Clinical campus the data sharing is necessary. Fast developments of modern technologies in telecommunications have a profound influence on the delivery of medical care throughout the world. Management decisions are therefore based upon a clinical history and an anatomical description of the radiographs. Verbal description of the diagnostic images of politraumatized patients, including musculoskeletal injuries can be insufficient. Utilizing a recent advance in telecommunications technology as higher resolution PDA phones handsets with multi-media messaging (MMS) service capability make digital capture and its transmission possible. Junior doctors due to their low experience sometimes look for some advice while evaluating radiograms even having the verbal description of the radiograph. In some cases it is of great benefit to view the images of the injury to plan further diagnostics or final treatment. A simple store and forward telemedicine system for transfer of the radiographs using MMS would help to make early, accurate management decisions. Usually, on-call or on duty trauma surgeon is unable to get internet access and is also insufficiently equipped. PDA phone multi-media messaging (MMS) capability is able to overcome obstacles of accessing the internet. Mobile phones or Mobile Digital Assistants become a new generation devices supplied with GPRS/3G wireless communication system. Mobile Personal Assistant (MDA) devices have changed the way of data and information exchange, share and storage. The use and interest in PDA/MDA devices rises particularly among physicians. A PDA Phone is a combination of mobile phone (cellular phone) and personal digital assistant functionality in one device. It differs from a smart phone in that it has a touch screen and a stylus. Compared with a smart phone it usually has a larger screen, a more powerful microprocessor, more memory, etc. In short, it functions more like a computer in its input/output of information. Nowadays diagnostic equipment used for diagnosis of politraumatized patients generates large number of images. Dramatic increase of image number was observed at the time of introduction of multislice CT scanners. Single examination may contain several hundreds of images. Specialists involved in treatment of critically injured patients require rapid access to these data. Cooperation among various specialists is time consuming when not efficient system for data and image transfer is available. PDA phones have been adopted and used to images accessing, collecting and transfer in clinical setting for decision support in trauma cases. We decided to perform the pilot study utilizing MMS in management of politraumatized patients to speed up diagnosis. The aim of the study was to evaluate the use of multi-media messaging as a supplement to the radiologist description of injures and to evaluate usefulness of PDA phones in daily clinical practice and emergency teleconsultation.

2. MATERIAL AND METHODS

There are still some hospitals located in several distant buildings without integrated PACS network. The facility, where the tests were performed, is located in several buildings standing separately without PACS network connection. Emergency and Orthopedic Trauma and Radiology Departments are located in opposite sections of the hospital (approx. 500 m distance). The facility is located in the area of fully supplied with 3G cellular network that enables data and image transfer with MDA (Mobile Digital Assistant) and/or mobile phones or internet. After the evaluation of a selection of advanced PDA mobile phone handsets, Qtek 2020 was taken into consideration for handset size and picture quality. Qtek 2020 device was chosen as the mobile platform to transmit and receive the multi-media messages (Fig. 1).

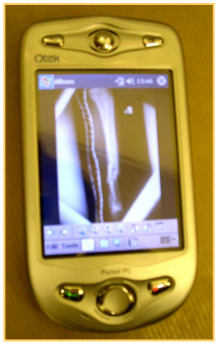

Fig. 1 Radiogram of the fractured tibia on PDA phone

Main unit with battery weighs approximately 190g and its maximal dimensions are 69,9 mm x130 mm x 19 mm that allows to be carried by the physician on duty at all times. The device is operating on Microsoft Windows Mobile 2003 for Pocket PC Phone Edition. It is equipped with 3.5” Transflective TFT-LCD with Back-light LEDs, 240 x 320 Pixels resolution, 64K Colors and Sensitive Touch Screen. The mobile phone in this model is based on fully Integrated GSM/GPRS Functional Block. Images were captured with built in CMOS color VGA camera (resolution 480x640). MMS client and image capture applications available in his PDA phone were utilized for the study. Plain images were captured by the referring orthopedic trauma surgeon or radiologist, saved in JPEG format and then transmitted as an MMS image to the handset of the other specialist (orthopedic trauma surgeon or radiologist). Images of diagnosed patient consisted of AP and lateral radiographs of the injured region, CT scans, US images, MRI images as well as a photograph of the clinically existing soft tissue complicating injury. Fifty images of conventional radiograms and CT scans were sent as MMS images. Teleconsultations were made between PDA phones through direct communication. Transferred image size was limited to 100 Kb. MMS messages were created and sent to provide fast teleradiologic consultation. Teleconsultations were performed between consultant radiologist and orthopedic trauma surgeon and vice versa. The acute duty emergency duty environment served as a study setting. Consecutive recruitment of diagnosed cases was chosen to avoid selection bias in radiograph quality or injury pattern. Radiographs and other diagnostic images were obtained in all the teleconsulted patients. Management decision was supplemented based on MMS images and the clinical history.

2.1. RESULTS

Image capture, selection of the Region Of Interest from clinically relevant image and its transmission and finally preparation of single MMS was never longer than 60 seconds. Transmission time for single multimedia message and its review by radiologist or orthopedic trauma surgeon was usually shorter than 10 minutes depending on specialist availability. All images sent via MMS reached somehow the recipient. Forty six of 50 MMS image reached PDA phone the others were redirected to MMS server. Other MMS were e-mailed to the address of the one consultant. Messages which did not received directly probably due to flight mode of the devices or some latency in message sending. Similarly, MMS transfer time from radiologist to clinician or opposite way to an e-mail account was always shorter than one minute. Quality of all CT images enabled consultations between specialists. Image quality of MMS radiograms accurate for teleradiologic assessment was confirmed in 46 MMS messages. Eight percent of X-rays were difficult to read. Ease of use of the MMS telemedicine system was judged to be highly acceptable.

3.1 DISCUSSION

PDAs an MDA devices are becoming increasingly popular among medical professionals [7, 10]. There has been widespread adoption of personal digital assistants (PDAs) within medicine in recent years [5-8, 11, 13, 16, 17, 22]. However, more than 75% of PDA users use only software such as drug databases and clinical references on their PDAs. Patient tracking applications, medical references and calculators, and documentation and billing software are also commonly used. Radiology-specific applications installed on PDA devices, is rarely used. Boon and Flanders surveyed radiologists [3] on PDA usage. They found that 45% of radiologists, mostly trainees use PDA devices. Less than 25% of them use radiology-specific applications. They concluded that along with higher display resolution, better wireless networking capabilities, greater memory capacity and increasing number of software applications dedicated to imaging, more radiologists in the future will use PDAs.

Dealing with emergency medicine and traumatology imaging information evaluation is demanded by radiologist and clinicians. Image transfer utilizing commonly available PDAs has been addressed by other investigators [10, 19, 25, 26, 27]. The 3G network has speed relatively approaching to the current broadband network, but the mobility is far greater than that of the broadband network. The resolution of a typical single slice of CT image of resolution 512 x 512 pixels consumes around 0.5 MB. This size file requires resizing for further transmission. This process will reduce the image detail to less than half of the image detail of the original DICOM image. The DICOM is the most common image format in PACS [12] designed for imaging scanners, computed radiography, film printers, and display workstations. At present there are a little display capabilities for PDA phone to present DICOM images.

The accuracy rate of 95% for image interpretation using a PDA was higher in the studies of Yaghmai et al. [24] than that reported by Reponen et al. [19]. Reponen et al. studied images of a resolution of 600 x 200 pixels, JPEG (Joint Photographers Expert Group) compression, and a lower gray scale setting of 8. False negative diagnostic error possibilities, nonsignificant for the management of the patient may occur as reported previously. The advent of wireless or GPRS/EDGE/UMTS operating PDA phone introduces the possibility of remote image interpretation and medical consultation. Evaluation of medical image by medical specialists based on remote transmission requires adequate, clinically relevant image quality. This study evaluated the capacity of the PDA phone to serve as a medium in the diagnostic interpretation of plain X rays CT scans of patients with multiple injuries. MDA and mobile phones allowed to see satisfactory images but rather informative than diagnostic. The rapid diagnosis of multiple injuries is crucial for favorable outcome. Personal digital assistants (PDAs) have been adopted and used within many disciplines for a number of different functionalities and healthcare is no exception. Healthcare professionals from physicians to pharmacists have adopted PDAs. That adoption has led to a number of different uses including decision support, education, and accessing or collecting data.

Multimedia Messaging Service (MMS) became a standard for a telephony messaging systems that allow sending messages that includes multimedia objects including images, audio, video and rich text. MMS is the evolution of Short Message Service (SMS - a text-only messaging technology for mobile networks). Mobile device has been designed to work with mobile packet data services such as GPRS. MMS was originally developed within the *Third-Generation Partnership Program* (3GPP), a standards organization focused on standards for the UMTS/GSM networks. Global availability makes cellular technology GPRS / EDGE / UMTS ideal for accessing MMS and email. However, the rates of data transmission are slower than wireless fidelity (WiFi) technology.

MMS requires a number of handset parameters to be set. Multi-media messaging service (MMS) capability allows the sending and receiving of images, movies and audio files. These devices are simple to use with sufficient quality of image resolution [20]. Implementing MMS has the potential to facilitate the rapid, relatively inexpensive teleconsultations to make an accurate management of politrauma and musculoskeletal injuries.

Display quality on PDA phones improves. Similar improvement is observed through image transfer speed while utilizing these devices [19, 25, 26]. A new method of portable image interpretation and display is able revolutionize the field of radiology and subspecialty medical consultation. Our data suggest that high-quality images from a radiogram or CT scan can be displayed on a PDA phone. Images transmitted through MMS can be interpreted with a degree of rather informative accuracy, but diagnostic accuracy can not be excluded a priori. The quality of the image was mostly screen size and resolution dependent. The smaller screen diminishes resolution and quality of images. Medical images evaluated on personal computers allowed getting reliable and diagnostically sufficient image resolution. Short transmission time confirmed by our study for images transmission create valuable tool for emergency images evaluation sufficient to prompt surgical or conservative management of the injured patient. Reponen et al. [19] reported a 1.5 minutes required for single image transmission time but the interpretation time of a complete CT was approximately 40 minutes. In future no complicated computer hardware or software should be necessary. An attractive telediagnostics solution utilizing MMS transfer is the simple e-mail sending. The MMS image transfer is simple and quick. Small objects were seen more clearly e.g. CT scans in comparison to conventional X rays while seen on PDA phone. We have found some difficulties to assess pictures with high contrast between elements resulting in blurring of the object edges and averaging of neighboring structures that were displayed in form of large rectangles in grayscale on PDA phone.

PDA phone radiology telemedicine allows high quality medical care and information to be delivered irrespective of geographic location. Several studies have shown benefits in remote emergency and trauma management [9, 21, 27]. Utilizing telemedicine in everyday clinical practice meets some obstacles as technology expenses, necessity of gaining a new skills in operating modern devices or software. Employing PDA phones as tools for telemedicine, already used by many physicians in their every day life it may be possible to overcome these obstacles [1, 15].

Internet mobile system for MMS transmission brings benefits delivering good enough quality of medical images immediately [2]. MMS enhances early decision making as the PDA phone handset can be carried on the orthopedic trauma surgeon at all times.

Fast teleconsultation system in politrauma must have zero tolerance for failure [2, 4]. Yaghmai et al. [24] described successfully a simple technique for transmission of a complete set of cranial computed tomography (CT) images to a commercially available wireless personal digital assistant (PDA) for remote teleradiology consultation. They retrieved, decompressed, and reviewed using PDA with cellular phone capability with commercially available software a complete set of images from the head CT of a trauma patient with subdural hematoma. Images were captured from a picture archiving and communication system (PACS) and transmitted wirelessly as an e-mail attachment. The time for entire procedure of complete CT image set capture, transmission and a remote radiologist’s wireless PDA consultation was shorter than 12 minutes [24].

In a few of the multi-media consults with the current system a redirection occurred to MMS server. That provoked the receiving delay probably due to a problem with GPRS bandwidth transmission. This problem should improve in the near future utilizing UMTS protocol. Message transmission security is an issue of highest concern, as in

all telemedicine applications. However, data on the mobile handsets can be secured by password protection, but encryption may protect transmission. For safety reasons personal data of the patient should be rather anonimized for the MMS teleconsultation. Maintaining patient data security particularly in a wireless environment is essential. For the safety reasons coding the attached image files and removing patient information from all images may become necessary procedure that may elongate the time to final description. Coded images must stay recognizable for the consultant not only for referring physician.

Another concern is mobile virus potential epidemics. The first mobile phone virus capable of replicating via MMS messages has been discovered. It targets Symbian Series 60 phones. Its ability to propagate via Multimedia Messaging Service messages (MMS) worries some experts. Fortunately, most of the PDA phones operate on Windows Mobile. Although mobile viruses are not currently a serious threat, some experts predict that the problem is on the rise and may become more widespread in the future. General rules to help protect the data on mobile device should be followed. Programs and content should be downloaded or accepted only from a trusted source. The device equipped with Bluetooth should remain turned off or set to non-discoverable mode when not used.

Yaghmai et al. [24] in their article presented a simple technique that allows rapid transmission of a complete head CT for consultation with a radiologist and trauma neurosurgeon at any remote location that has cellular telephone service. They were able to transmit a complete head CT by compressed to smaller in size .pdb file format to prompt the file transmission. That form of compression allows to transmit and review an entire set of images, unlike the previously reported studies in which only selected images are transmitted [24, 26]. The consultant may be situated in a different country or continent and far from a landline but must stay within cellular network environment.

In the present study, we also show that these images may be displayed rapidly and with the accurate quality anywhere with mobile network. Presented technique may therefore be utilized in a remote location for evaluation and triage of traumatized patients. The rapid image transmission may differ dependently on clinical settings.

4.1 CONCLUSIONS

We have demonstrated the feasibility of using PDA phone in accessing digital medical images. Devices equipped with digital cameras for image and video capture can be used as an efficient tool facilitating rapid diagnosis in politrauma patients. MMS images with limited size files allowed receiving informative, but not always fully diagnostic teleconsultation. No discrepancies were found when comparing treatment recommendations based on the PDA images to those based on images on PACS. The image detail is limited by its resolution and display intensity in the mobile display, although PDA phone device can provide fast delivery of images such that radiologists can preview images before they have access to an image workstation. The system tested in our pilot study is particularly important in the case of urgent consultation and clinicians can review reported images through mobile phone display. It could be of value for referring clinicians to obtain relevant images and accompanying diagnostic reports. Using the PDA phones trauma radiologists and trauma surgeons achieve enhanced and rapid access to images that facilitates care of trauma patients.

ACKNOWLEDGEMENTS:

The authors would like to thank Polkomtel S.A. and in particular Mr Mariusz Gil, Sławomir Pac-Pomarnacki, Maria Łysakowska and Janusz Turczynowicz for their time and help towards the study.

BIBLIOGRAPHY

[1] Angood P.B., Telemedicine, the Internet, and World Wide Web: overview, current status, and relevance to surgeons, World J Surg., Volume: 25, (2001), pp. 1449—1457
[2] Archbold H.A.P. , Guha A.R., Shyamsundar S., McBride S.J., Charlwood P., Wray R. The use of multi-media messaging in the referral of musculoskeletal limb injuries to a tertiary trauma unit using: a 1-month evaluation Injury, 2005, 36, 4, 560-566
[3] Boonn W.W., Flanders A.E. Survey of Personal Digital Assistant Use in Radiology RadioGraphics 2005; 25:537–541
[4] Burdick A.E., Mahmud K., Jenkins D., Telemedicine: caring for patients across boundaries, Ostomy Wound Manage., Volume: 42, (1996), pp. 26-30
[5] Busch JM, Barbaras L, Wei J, Nishino M, Yam CS, Hatabu H. A mobile solution: PDA-based platform for radiology information management. AJR Am J Roentgenol 2004; 183:237–242
[6] Criswell DF, Parchman ML. Handheld computer use in U.S. family practice residency programs. J Am Med Inform Assoc 2002; 9:80–86
[7] Fischer S, Stewart TE, Mehta S, Wax R, Lapinsky SE (2003) Handheld computing in medicine. J Am Med Inform Assoc 10:139–149
[8] Flanders AE, Wiggins RH III, Gozum ME. Handheld computers in radiology. RadioGraphics 2003; 23:1035–1047
[9] Garner P., et al. Mobile telecare—a mobile support system to aid provision of community based care, J Telemed. Telecare., Volume: 2, (1996), 39-42
[10] Glinkowski W; Ciszek B, Gil M. Teleconsultations in orthopedic trauma and neurotrauma utilizing mobile digital assistant *International Congress Series* 2005, 1281, 1329
[11] Greenberg R. Use of the personal digital assistant (PDA) in medical education. Med Educ 2004; 38:570–571
[12] Huang, HK: PACS: Basic Principles and Applications New York: Wiley, 1999
[13] Joy S, Benrubi G. Personal digital assistant use in Florida obstetrics and gynecology residency programs. South Med J 2004; 97:430–433
[14] Kondo Y. Medical image transfer for emergency care utilizing internet and mobile phone. Nippon Hoshasen Gijutsu Gakkai Zasshi 2002; 58:1393-1401
[15] Lowery J.C., Hamill J.B., Wilkins E.G., et al. Technical overview of a web-based telemedicine system for wound assessment, Adv. Skin Wound Care., 2002, 15, 165-169
[16] McLeod TG, Ebbert JO, Lymp JF. Survey assessment of personal digital assistant use among trainees and attending physicians. J Am Med Inform Assoc 2003; 10:605–607
[17] Raman B, Raman R, Raman L, Beaulieu CF. Radiology on handheld devices: image display, manipulation, and PACS integration issues. Radio-Graphics 2004; 24:299–310
[18] Ratib O, McCoy JM, McGill DR, Li M, Brown A. Use of personal digital assistants for retrieval of medical images and data on high-resolution flat panel displays. RadioGraphics 2003; 23:267-272
[19] Reponen J, Ilkko E, Jyrkinen L, Tervonen O, Niinimaki J, Karhula V, et al Initial experience with a wireless personal digital assistant as a teleradiology terminal for reporting emergency computerized tomography scans. J Telemed Telecare 2000, 6:45–49
[20] Reponen J., Iikko E., Jyrkinen L., Karhula V., Tervonen O., Laitinen J., et al. Digital wireless radiology consultaions with a portable computer, J Telemed Telecare 1998, 4, 201-205
[21] Sani-Kick S., Gmelin M., Schochlin J., Bolz A., Recording and transmission of digital wound images with the help of a mobile device, Biomed Tech (Berl), Volume: 47, Issue: Suppl 1 Pt 2 (2002), pp. 968-969
[22] Wiggins RH III. Personal digital assistants. J Digit Imaging 2004; 17:5–17
[23] Xu Z, Yamauchi K, Ikeda M, Yang S, Hasegawa Y. Evaluation of a PC-based teleconferencing system for reading chest radiographs. J Telemed Telecare 1999; 5:122-125
[24] Yaghmai V, Salehi S.A., Kuppuswami S, Berlin J. W. Rapid wireless transmission of head CT images to a personal digital assistant for remote consultation Academic Radiology 2004, 11, 11, 1291-1293
[25] Yamada M, Watarai H, Andou T, Sakai N (2003) Emergency image transfer system through a mobile telephone in Japan: technical note. Neurosurgery 52:986–990

[26] Yamamoto L.G., Williams D.R., A demonstration of instant pocket wireless CT teleradiology to facilitate stat neurosurgical consultation and future telemedicine implications, *Am J Emerg Med*, 2000, 18, 423—426

[27] Yamamoto LG. Wireless teleradiology and fax using cellular phones and notebook PCs for instant access to consultants. Am J Emerg Med 1995; 13:184-187