Modifying Clinicians Use of PACS Imaging

Madusha Chandratilleke · Stephen Honeybul

Published online: 14 May 2013
© Society for Imaging Informatics in Medicine 2013

Abstract The purpose of this study was to determine whether it would be possible to minimise the delay that occurs between the time a radiological image becomes available for viewing on PACS and the time that it is actually seen by the requesting physician. The study was conducted at Sir Charles Gairdner Hospital in Perth Western Australia. Participants in the study were all junior doctors. The first part of the study measured the current time delay between images being available on PACS and actually being viewed. In the second part of the study, the doctors were notified by a paging system when the images were available. The reduction in time delay was then compared. Following pager notification, the mean average time delay reduced from a mean of 180.02 min (95 % confidence interval (CI), 135.1 to 225 min) to a mean of 33.94 min (95 % CI, 24.1 to 43.8 min; $P < 0.0001$). The study has demonstrated that it is possible to modify clinicians' usage of PACS; however, there remain questions regarding the sustainability of such an intervention and the impact that this may have on overall patient outcome. There may be potential for integration of the rapidly expanding technologies such as tablets, iPads and iPhones in order to automate this type of notification and this may be a focus of future research.

Keywords PACS management · PACS reading · Time and motion studies

Introduction

Picture Archiving and Communication Systems (PACS) provide a centralized repository for all imaging data and have been developed in order to provide clinicians with

access to diagnostic images and reports at the point of care. This negates the requirement for a film-based system and the expectation has always been that this would streamline health care delivery, facilitate more efficient patient care processes and ultimately improve clinical outcomes.[1,2]

There can be little doubt that its implementation has had a significant impact on many facets of clinical practice and a number of studies have demonstrated considerably improved efficiencies particularly within the radiology department. This has often been achieved by simplifying workflow practices and eliminating a number of previously time-consuming aspects of radiological reporting.[1,3–8] In addition, clinicians save a considerable amount of time because films do not get lost and staff can retrieve images from workstations throughout the hospital without the need to be pulled away from patients in order to view images in the radiology department.[2,5,8–11] Finally, PACS allows status checking of patients and examinations so that clinicians can easily check whether an image has been taken, stored and reported by a radiologist.[5,11]

However, despite these improvements in work flow practices it has yet to be established that these efficiencies have been translated into an improvement in clinical outcome.[12,13] Indeed for the PACS system to provide measureable clinical benefit, the images must not only be produced earlier but also viewed and then *acted upon* such that patients receive more timely health care provision.

The aim of this pilot study was firstly, to determine the time delay between images becoming available on the PACS system and being actually viewed by the requesting clinician. The second aim was to determine the impact that a pager notification to the requesting clinician had on this time delay.

Methods

The study was conducted at Sir Charles Gairdner Hospital, which is one of the major tertiary referral hospitals in Perth, Western Australia. The study was part of a hospital-sponsored initiative aimed at improving patient care. Hospital research

M. Chandratilleke · S. Honeybul
Department of Neurosurgery, Sir Charles Gairdner Hospital,
Perth, Western Australia, Australia

M. Chandratilleke · S. Honeybul (✉)
Department of Neurosurgery, Royal Perth Hospital,
Perth, Western Australia, Australia
e-mail: stephen.honeybul@health.wa.gov.au

ethics committee approval was obtained. The study was conducted over a 2-month period amongst junior medical officers covering five specialties. The five participating specialties were General Medicine, General Surgery, Vascular Surgery, Neurosurgery and Orthopaedic Surgery. In order to obtain an understanding of the radiology within this particular hospital, the senior author (MC) spent one day following the path of a request form from reception to the final report. In order to prevent participation bias, the study was conducted by the senior author who is a junior doctor at Sir Charles Gairdner Hospital.

Data Collection and Analysis Prior to Pager Notification

In the first part of the study, participants placed a request for a particular radiological image. They were then asked to manually record the time and date at which they viewed each image. Participants were also asked to document any variations from their normal practice. These included factors such as being contacted by radiology registrar, actively requesting a report from a radiologist or discussing the results at a multidisciplinary meeting. All radiologists on the general radiology roster participated. At this institution, all junior radiologists are directly supervised by senior colleagues. Data were collected over 10 working days for a total of 45 patients. The data recorded by the participants were compared to the information on the Radiology Information System where data regarding the time of request and the time at which the image was completed and ready for viewing on the PACS system were recorded automatically. The imaging modalities included in the study were X-ray, CT, MRI, US and bone scan.

Participant Group Discussions

The initial data were then analysed and presented to seven junior doctors in the setting of a small seminar. At this seminar, the participants were asked what they felt to be the five main reasons that there was a delay in time between the imaging becoming available and actually being viewed. These reasons were then grouped and voted on by the same seven doctors which resulted in their top three reasons for the delay. Thereafter, a larger group of doctors were presented with these three reasons, and they were asked to rank each reason in order of priority. The top three reasons included:

1. Unable: The requesting doctor is unable to view the image because they are physically away from a computer
2. Unaware: The requesting doctor is unaware that the image is available, otherwise would be able to view it
3. Unnecessary: The test result has no immediate impact on the patient's management (i.e. monitoring decrease of a pleural effusion where the patient is symptomatically well)

Of these three options, 72 % (33/46) voted that reason 2, Unaware, was the biggest contributor to the 3-h time delay from image availability to image viewing.

Data Collection and Analysis After Pager Notification

In the second part of the study, which was conducted over a 6-day period, junior doctors were manually paged once the images became ready for viewing on PACS. This was performed by the senior author who, between the hours of 0800 and 1700, would send a LAN page (base page) message to the requesting doctor of each newly completed image. The page notification was sent up to a maximum of 30 min after the imaging had been completed and was ready for viewing. The paged message would read 'Mr./Mrs. X's image is available for viewing'. Only surnames were used, and no other identifying feature such as date of birth or patient record number was included in the message. The time at which the images were actually viewed by the junior doctor were re-collected using the same method as the initial data set, where each doctor manually recorded the time and date at which they viewed each image.

Data Presentation and Group Discussion After Pager Notification

At the end of the study period, the doctors were presented with the findings, and at this time, their views were canvassed regarding the possible advantages or disadvantages of a pager notification system.

Exclusions

Any instances in which the JMO was contacted by Radiology directly or the doctor was not working due to a public holiday were deleted from the data set. The working day was taken to be between 7 a.m. and 5 p.m., and results outside these hours were excluded.

Results

Twenty junior doctors participated in the study.

Analysis of Data Prior to Pager Notification

Data were analysed from 45 radiology requests. Initially, the mean average time delay between the images becoming available and being actually viewed was 180.02 min (95 % confidence interval (CI), 135.1 to 225 min). The median time delay was 118 min (maximum delay, 622 min, minimum delay, 6 min; interquartile range, 73 to 249 min). Ninety per cent of images were seen after midday, with 34 % seen after 1700 hours.

Group Discussions

In the initial small group discussions amongst seven junior doctors, the top three reasons for this delay was felt to be:

1. Unable: too busy
2. Unaware: no feedback
3. Unnecessary: irrelevant investigation

When opinion was canvassed amongst a larger group of 46 junior doctors, 72 % (33 out of the 46) felt that the delay was due to having ‘no feedback’ regarding imaging availability.

Analysis of Data After Pager Notification

The post-trial data were collected for 52 patients across eight inpatient specialties. These included General Medicine, General Surgery, Neurosurgery, Orthopaedic Surgery, Cardiothoracic Surgery, Hepatology, Renal Medicine and Respiratory Medicine. Following pager notification, the mean average time delay reduced from a mean of 180.02 min (95 % CI 135.1 to 225 min) to a mean of 33.94 min (95 % CI 24.1 to 43.8 min; $P < 0.0001$). The median time delay was reduced from 118 to 22 min (maximum delay, 135 min; minimum delay, 0 min; interquartile range, 3 to 61 min).

The number of images viewed after midday reduced from 90 % to 50 %. The number of images viewed after 17.00 reduced from 34 % to 0 %.

Participants were also asked to record their personal views regarding the impact of the pager notification had

on their day to day practice. Overall, the participants’ views were positive (Table 1).

Discussion

As medical technology continues to rapidly advance, there is a growing awareness that health care systems must be adequately integrated in order to ensure that they are introduced and applied in a timely and organised manner. This will ensure that the health care system, as a whole, functions efficiently and there is an adequate return on what can be a substantial financial investment.[11,14,15]

Introduction of PACS

The PACS is one such system that has evolved considerably over the past 30 years from what were initially in-house radiology systems to the contemporary hospital-wide commercial systems that have expanded to incorporate technologies such as voice recognition and computer-aided diagnostic systems.[6,16,17] However, despite the almost universal acceptance into the modern health care setting, there is relatively little evidence that it has improved clinical outcomes and this is perhaps not entirely unsurprising. Most studies have focused on quantitative, analytical aspects of workflow practices, whereas many of the improvements will be qualitative and more difficult to quantify.[1,3,4,6–8,18,19] In addition, overall clinical outcome relates to many factors other than radiological investigations in what is often multifactorial healthcare

Table 1 Views expressed by participants regarding what they felt to be the advantages of pager notification

Some of the participants’ individual volunteered responses

Question 1: Do you feel that having a radiology notification system benefitted you and your organization of daily duties?

“Yes. Very beneficial especially with regards to optimizing time efficiency Time saving - didn’t waste time making sure images were available”

“Notification helped in saving time by not having to check PACS repeatedly and also by not wasting time post image (able to act on result faster)”

“Found the paging to be helpful otherwise I probably wouldn’t have sighted the imaging til the afternoon.”

“Absolutely! Very helpful on a busy term to not have to constantly check for scans not done and pages lessened time before review, ward was more efficient”

Question 2: Do you feel as if it benefitted your patients?

“Yes, prompt evaluation and review of imaging therefore quicker implementation of care/management for the patient”

“Yes, early viewing of imaging resulted in early assessment of problems and early operation”

“Yes – makes sure images were done on time ie if not paged by afternoon could follow up. – Urgent images were looked at ASAP”

“Yes, helps decisions to be made sooner regarding their management. Shorter delays to intervention and changes in management”

In summary

As evidenced above, there were high levels of satisfaction from all staff involved regarding a notification system for radiology with reported increased working efficiency and shorter delays to intervention and changes in management. A notification system also has the benefits of urgent imaging being viewed immediately and acted upon earlier as well as less ‘missed’ pathology and errors. As previously discussed, recollection of this data in a larger cohort may reveal further improvements in length of stay and number of hours of overtime worked by staff.

provision. It may be very difficult if not impossible to demonstrate that the introduction of PACS has had a significant effect on the broader clinical picture and traditional outcome measures such as length of stay.[8,11,20,21]

The Current Study

A more realistic approach may be to analyse the way clinicians currently utilize the PACS technology and thereafter attempt to modify individual steps in the process such that it becomes more clinically efficient. The aim of the current study was to modify one aspect of established clinical practice. This approach differs from most of the previous studies that have focused on how the *introduction* of PACS has influenced clinical practice rather than how clinical practice may be modified once the technology has become established. The findings demonstrate that manually paging a doctor once a requested image becomes available considerably shortens the time between an image being available for viewing and it actually being seen by the requesting clinician. Similar reductions were demonstrated in studies investigating the impact that the introduction PACS had on the time to view images.[12,22–24] The question remains as to whether this will actually provide worthwhile clinical benefit and whether this type of intervention is indeed sustainable.

Advantages of Early Clinician Notification

The current study has clearly demonstrated that one of the reasons that clinicians are not able to act on radiological findings is because they are not aware that the images are available for viewing. This has been noted in previous studies which have proposed that an appropriate “flag” may be required in order to alert clinicians.[10,12,17,25,26]

Overall, the comments from participants were very positive and participants consistently commented that they felt that the notification system was very beneficial especially with regard to optimising time efficiency. None of the participants felt that the notification was either detrimental or intrusive and many stated that they felt more confident knowing that they were going to be “reminded” about an investigation that they may have requested a number of hours previously. Although the responses were universally positive, it would be difficult to substantiate the comments from the participants who felt that patient care and outcome was improved. It would be more realistic to state that one small part of patient care has been made more efficient and perhaps by making further targeted improvements in working practices overall health care delivery will be made more efficient. One of the key advantages that was not commented on was the reduction in the number of times the images were reviewed after working hours. This fell

from 34 % prior to implementation of the notification system to 0 % after implementation. In the environment of ever increasing cost efficiencies, this may have implications regarding overtime worked by staff.

Limitations of the Current Study and Future Directions

The question remains as to whether or not this type of early notification system would be sustainable. Certainly it was time consuming and labour intensive for the senior author to manually notify what was in effect, a relatively small group of doctors over a relatively short time period. To become sustainable, this working model would have to be considerably modified in order to be cost effective. Although the technology is now available not only for automated paging systems but also for multimodality viewing of images, we do not currently have these facilities at our institution. In order to justify the expense of incorporating these technologies into existing radiological systems, there has to be some evidence available regarding the benefits provided in terms of clinical efficiency.

What this study has done is demonstrate how one small part of clinical practice can be consistently modified and there are a number of avenues that can be developed. In the current study, there was no prioritization given to the urgency of the investigation as this was a preliminary study looking at routine day to day practice. However, given the results of this study, it would seem logical to incorporate the level of urgency into any notification system. Further benefits may well come with the increasing availability of rapidly expanding technologies such as tablets, iPads and iPhones. There would appear to be little doubt that there is potential for clinicians to obtain instant access to imaging information at the point of care. The benefits of using these types of dispatching systems and the quality provided will require validation and issues regarding patient confidentiality will need to be addressed.

Future research will determine whether these almost ubiquitous technologies can be integrated into the established radiology systems. It may be unrealistic to expect measureable improvements in clinical outcome; however, it is hard to see how improving individual steps in the overall health care provision can be anything other than beneficial.

References

1. Halsted MJ, Froehle CM: Design, implementation, and assessment of a radiology workflow management system. *AJR Am J Roentgenol* 191:321–327, 2008
2. van de Wetering R, Batenburg R, Versendaal J, Lederman R, Firth L. A balanced evaluation perspective: picture archiving and

- communication system impacts on hospital workflow. *J Digit Imaging* 19 Suppl 1:10–7, 2006
3. Mackinnon AD, Billington RA, Adam EJ, Dundas DD, Patel U: Picture archiving and communication systems lead to sustained improvements in reporting times and productivity: results of a 5-year audit. *Clin Radiol* 63:796–804, 2008
 4. Nitrosi A, Borasi G, Nicoli F, Modigliani G, Botti A, Bertolini M, Notari P: A filmless radiology department in a full digital regional hospital: quantitative evaluation of the increased quality and efficiency. *J Digit Imaging* 20:140–148, 2007
 5. Pilling JR: Picture archiving and communication systems: the users' view. *Br J Radiol* 76:519–524, 2003
 6. Siegel EL, Reiner BI: Filmless radiology at the Baltimore VA Medical Center: a 9 year retrospective. *Comput Med Imaging Graph* 27:101–109, 2003
 7. Siegel EL, Reiner B: Work flow redesign: the key to success when using PACS. 2002. *J Digit Imaging* 16:164–168, 2003
 8. van de Wetering R, Batenburg R: A PACS maturity model: a systematic meta-analytic review on maturation and evolvability of PACS in the hospital enterprise. *Int J Med Inform* 78:127–140, 2009
 9. Cox B, Dawe N: Evaluation of the impact of a PACS system on an intensive care unit. *J Manag Med* 16:199–205, 2002
 10. Srinivasan M, Liederman E, Baluyot N, Jacoby R: Saving time, improving satisfaction: the impact of a digital radiology system on physician workflow and system efficiency. *J Healthc Inf Manag. Spring* 20:123–131, 2006
 11. Ondo K: PACS direct experiences: implementation, selection, benefits realized. *J Digit Imaging* 17:249–252, 2004
 12. Kundel HL, Seshadri SB, Langlotz CP, Lanken PN, Horii SC, Nodine CF, Polansky M, Feingold E, Brikman I, Bozzo M, Redfern R: Prospective study of a PACS: information flow and clinical action in a medical intensive care unit. *Radiology* 199:143–149, 1996
 13. Westbrook JI, Braithwaite J: Will information and communication technology disrupt the health system and deliver on its promise? *Med J Aust* 193:399–400, 2010
 14. Henderson JC, Thomas JB: Aligning business and information technology domains: strategic planning in hospitals. *Hosp Health Serv Adm* 37:71–87, 1992
 15. Goldszal AF, Blesman MH, Bryan RN: Financing a large-scale picture archival and communication system. *Acad Radiol* 11:96–102, 2004
 16. Faggioni L, Neri E, Castellana C, Caramella D, Bartolozzi C: The future of PACS in healthcare enterprises. *Eur J Radiol* 78:253–258, 2011
 17. Lemke HU: Short history of PACS (Part II: Europe). *Eur J Radiol* 78:177–183, 2011
 18. Fridell K, Edgren L, Lindsköld L, Aspelin P, Lundberg N: The impact of PACS on radiologists' work practice. *J Digit Imaging* 20:411–421, 2007
 19. Hains IM, Georgiou A, Westbrook JI: The impact of PACS on clinician work practices in the intensive care unit: a systematic review of the literature. *J Am Med Inform Assoc* 19:506–513, 2012
 20. Watkins J, Weatherburn G, Bryan S: The impact of a picture archiving and communication system (PACS) upon an intensive care unit. *Eur J Radiol* 34:3–8, 2000
 21. Hurlen P, Østbye T, Borthne AS, Gulbrandsen P: Does improved access to diagnostic imaging results reduce hospital length of stay? A retrospective study. *BMC Health Serv Res* 10:262, 2010
 22. Arenson RL, Seshadri SB, Kundel HL, DeSimone D, Van der Voorde F, Gefer WB, Epstein DM, Miller WT, Aronchick JM, Simson MB, et al: Clinical evaluation of a medical image management system for chest images. *AJR Am J Roentgenol* 150:55–59, 1988
 23. De Simone DN, Kundel HL, Arenson RL, Seshadri SB, Brikman IS, Khalsa SS, Davey MJ, Brisbon NE: Effect of a digital imaging network on physician behavior in an intensive care unit. *Radiology* 169:41–44, 1988
 24. Humphrey LM, Fitzpatrick K, Atallah N, Ravin CE: Time comparison of intensive care units with and without digital viewing systems. *J Digit Imaging* 6:37–41, 1993
 25. Weatherburn G, Bryan S, Nicholas A, Cocks R: The effect of a picture archiving and communications system (PACS) on diagnostic performance in the accident and emergency department. *J Accid Emerg Med* 17:180–184, 2000
 26. Horii S, Redfern R, Feingold E, Kundel H, Nodine C, Arnold D, Abbuhl S, Lowe R, Brikman I: An automated results notification system for PACS. *J Digit Imaging* 14:192–198, 2001