Incorporation of a Formalized Emergency Radiology Curriculum to Facilitate Population of a MIRC-based Digital Teaching File

Frank J. Welte,¹ Sunah C. Kim,¹ Devang J. Doshi,¹ Stephen C. O'Connor,¹ and Bret F. Coughlin^{1,2}

Teaching files are integral to radiological training. Digital Imaging and Communication in Medicine compatible digital radiological data and technological advances have made digital teaching files a desirable way to preserve and share representative and/or unusual cases for training purposes. The Medical Imaging Resource Community (MIRC) system developed by the Radiological Society of North America (RSNA) is a robust multi-platform digital teaching file implementation that is freely available. An emergency radiology training curriculum developed by the American Society of Emergency Radiology (ASER) was incorporated to determine if such an approach might facilitate the entry, maintenance, and cataloguing of interesting cases. The RSNA MIRC software was obtained from the main MIRC website and installed. A coding system was developed based on the outline form of the ASER curriculum. Weekly reports were generated tallying the number of cases in each category of the curriculum. Resident participation in the entry and maintenance of cases markedly increased after incorporation of the ASER curriculum. The coding schema facilitated progress assessment. Ultimately, 454 total cases were entered into the MIRC database, representing at least 42% of the subcategories within the ASER curriculum (161 out of 376). The incorporation of the ASER emergency radiology curriculum greatly facilitated the location, cataloguing, tracking, and maintenance of representative cases and served as an effective means by which to unify the efforts of the department to develop a comprehensive teaching resource within this subspecialty. This approach and format will be extended to other educational curricula in other radiological subspecialties.

KEY WORDS: Medical Imaging Resource Center (MIRC), electronic teaching file, emergency radiology, experiential, Extensible Markup Language (XML), web technology, computers in medicine, computer communication networks, data mining, database management systems, digital libraries, education, medical, image libraries, radiology teaching files, teaching

BACKGROUND

Radiologists have always collected interesting studies for teaching purposes and these collected teaching files continue to be integral to radiological training. Case conferences and apprenticeship have traditionally been used to guide self-directed learning and review of numerous cases present within a departmental teaching file can facilitate this learning process. A physical teaching file based upon categorized hard copies has inherent limitations, including space requirements, degradation and physical damage of films over time, the cumulative loss of loaned films, and difficulty in cataloguing and tracking cases contained within the repository. Furthermore, as senior physicians retire, a wealth of interesting

¹From the Department of Radiology, Baystate Medical Center, Tufts University School of Medicine, 759 Chestnut Street, Springfield, MA, USA.

²From the Department of Radiology, Hartford Hospital, 85 Seymour Street, Suite 200, Hartford, CT, USA.

Electronic supplementary material The online version of this article (doi:10.1007/s10278-009-9178-8) contains supplementary material, which is available to authorized users.

Correspondence to: Frank J. Welte, Department of Radiology, Baystate Medical Center, Tufts University School of Medicine, 759 Chestnut Street, Springfield, MA, USA; e-mail: ffwelte@gmail.com

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Online publication 13 February 2009

cases is often lost or poorly transferred to the next curator of their individual collection. Teaching files in any form are not static and require constant maintenance and updating due to improvements in technology and development of new imaging modalities and methods as well as new insights into disease diagnosis and pathophysiology.

DICOM (Digital Imaging and Communication in Medicine) compatible digital radiological data and technological advances have made digital teaching files a more desirable way to preserve and share representative or unusual cases for training purposes. The widespread availability of film scanning technology allows traditional hard copy studies to be preserved and incorporated into a more robust digital framework.

The typical approach by which an institutional teaching file is accumulated is simply the addition of cases as they are encountered, with little communication or coordination between radiologists. There are differing opinions regarding whether a shared institutional teaching file or a personal collection of cases is preferred. Anecdotal experience has shown that an uncoordinated approach can lead to a poorly representative collection of cases within the repository and a lack of overall knowledge of the categories of cases present within the department or even within one's own collection. A useful teaching file would ideally contain a representative collection of both common and uncommon cases within all subspecialties of interest, these cases being locatable, well documented, and preserved.

Faculty and residents in the Baystate Medical Center radiology department desired an easily adaptable teaching file system and a means of populating it efficiently. It was hypothesized that the use of a formalized emergency radiology training curriculum would facilitate the population of a departmental teaching file. The Medical Imaging Resource Community (MIRC) system developed by the Radiological Society of North America (RSNA) is a robust multi-platform digital teaching file implementation that is actively developed and freely available. A MIRC system was locally implemented and an emergency radiology training curriculum developed by the American Society of Emergency Radiology (ASER) was utilized to determine if this approach might facilitate the entry, maintenance, and cataloguing of interesting cases within this subspecialty.

METHODS

MIRC Site Installation

The RSNA MIRC software has been previously described¹⁻⁷ and detailed MIRC documentation is available online^{8,9}. The RSNA MIRC software (v. T27h) was installed in an off-site location on a Mac G4 500 MHz dual processor desktop computer running OS X (v. 10.4.10; Apple Computers, Cupertino, CA, USA). Individual user accounts were created for each resident and faculty member. A pre-packaged version of the Jakarta Tomcat (v. 4.1.24) Java-based web server software (The Apache Software Foundation, Forest Hill, MD, USA)¹⁰ referred to as "CompleteTomcat"¹¹ was also installed. The Tomcat installation was later upgraded to v. 5.5.12. Source code for Jakarta Tomcat can be found at the main Apache site¹². The free ClamAV (SourceFire, Columbia, MD, USA) antivirus software with the ClamXav (Mark Allan, Edinburgh, Scotland) Graphical User Interface (GUI) was installed.

As is the case at many institutions attempting to develop digital teaching files, no long-term institutional Information Technology support could be allocated for this project. For this reason, a MIRC server was installed off-site, using our institutional guidelines for Health Insurance Portability and Accountability Act (HIPAA) compliance. An upgraded residential cable modem Internet connection and Internet Service Provider (ISP; Comcast, Philadelphia, PA, USA) were employed for data communication with a server peak download speed of 16 Mbps (Megabits/second) and peak upload speed of 768 Kbps (Kilobits/second). Typical residential high speed Internet connections are subject to Internet Protocol (IP) address changes at varying frequencies—a configuration known as a dynamic IP address. Because the IP address of the host computer is used by client computers to locate the MIRC site via a Domain Name System (DNS) server, either a static IP address (and domain name) must be purchased at considerable cost or some means of regularly communicating the host computer's current IP address to the world must be instituted.

The free version of the No-IP.com DNS routing service was implemented on the host computer. The No-IP.com parent server received the current IP address of the local host computer from a small

application running on the host computer at user-definable intervals and associated this IP address with a fixed domain name (bmcmirc.no-ip.org in this case), which successfully overcame the dynamic IP limitation¹³. The No-IP.com service essentially mapped the dynamic IP address of the MIRC site onto one of the fixed No-IP.com IP addresses, which was transmitted to DNS servers globally. When requests for this address arrived at No-IP.com, the service relayed the request to the appropriate dynamic IP address. No MIRC database information or Protected Health Information (PHI) was transmitted through the No-IP.com service. Compliance with HIPAA is built into the MIRC site installation configuration, including logging of individual record accesses and the ability to generate audit reports.

Image annotation within the installed version of the MIRC software relies upon the Java Advanced Imaging (JAI; Sun Microsystems, Santa Clara, CA, USA) addition to the Java runtime environment and is built into the MIRC installation⁸, which was downloaded and installed separately.

Backup of the entire MIRC system and data to an external Firewire hard drive (Fantom Titanium II, Fantom Drives, Torrance, CA, USA) was performed nightly using the commercial version of the SuperDuper (v. 2.1.4) program (Shirt Pocket Software, Weston, MA, USA). Additional periodic backups to optical disks were performed. Although cases were anonymized and no PHI was included in the MIRC database, the backup hard drive and backup optical disks were all stored in a locked, secure location. New cases were reviewed in detail on a weekly basis to ensure that no PHI was inadvertently entered or retained in the database.

Using readily available hardware, technologies, and software, installation and maintenance of a stand-alone, off-site MIRC digital teaching file system was straightforward. The overall system as configured was quite stable, typically running for months at a time without requiring restart or significant intervention. The automated backup process was transparent and reliable.

The time to perform the initial installation of the MIRC system was approximately 4 h. A total of 25 user accounts were initially created (15 residents and ten faculty). Review of the ASER curriculum and devising a coding schema required approximately 2 h. Creating user accounts for each of the

faculty and residents required 1 h. Daily maintenance of the MIRC system required only 10–20 min at most and involved verifying that backups had been performed, that the system was running correctly, and that cases were being stored in the system correctly. Generation and distribution of reports required approximately 1 h per week.

Due to technical difficulties with implementation, neither the HTTPS encrypted protocol nor a Virtual Private Network (VPN) was employed. Stripping cases of PHI allowed the use of a non-encrypted network connection; however, this had the downside of making case tracking and later modification somewhat problematic.

CASE CODING AND TRACKING

To facilitate tracking and sorting of cases, a coding schema based upon the ASER curriculum^{14,15} was developed. Similar coding systems have previously been employed for this purpose (see, for example, Ref. 16).

ASER curriculum categories and subcategories with imaging correlates were assigned unique codes based on a collapsed outline rule. For example, the first portion of the ASER outline is as follows:

A. Central Nervous System

1. Skull fractures
2. Extra-axial hemorrhages
 - a. subdural hematoma
 - b. epidural hematoma
 -
 -
 -

An example of a skull fracture would be coded as “ED:A1,” whereas an example of an epidural hematoma would be “ED:A2b.” Relevant codes for each case were manually entered into the “Keywords” field. Cases with multiple diagnoses were coded with all applicable codes in the “Keywords” field separated by commas. Proper coding of cases was verified on a weekly basis. The full coding schema can be seen in the sample report included in the [Electronic supplementary material](#).

CASE IDENTIFICATION AND ENTRY

Individual residents and attending physicians reviewed weekly reports containing information on the types of cases still needed within the MIRC database and used this information to guide case identification. Each resident in the department was also required to identify and enter into the teaching file at least two cases per month, although this requirement was not strictly enforced. The database administrator manually verified the number of cases entered by each resident by searching for cases authored by each individual on a weekly basis. No limitations on case entry were imposed, i.e., multiple examples of any disease category were allowed if the physician identifying the case felt that they should be included.

The threshold for determining whether a case should be included in the database was variable and left up to each individual. The highest priority was typically given to cases not yet represented in the database. As better examples of each disease entity were identified, these cases were queued for database entry. Cases deemed no better examples of a given coding subcategory were entered at a somewhat lower priority, but not altogether dismissed, as additional examples of each subcategory were felt to be helpful for training purposes. Inclusion of variant manifestations of disease entities was particularly encouraged.

Non-emergency cases were also entered to a lesser degree, but not tabulated in the weekly reports, unless they were in some way related to a coded ASER subcategory, in which case they were given a subcategory specific "Other" code. For example, a difficult to categorize case presenting in the emergency department might be simply coded as "ED:Other," whereas a male genitourinary (GU) emergency case not falling within the ASER-specified curriculum subcategories would be coded as "ED:H," since all male GU emergency subcategories begin with "ED:H."

Cases were entered using either the built-in web-based MIRC case entry tool or the standalone RadPix program (v. 3.15b-146; Weadock Software, LLC, Ann Arbor, MI, USA)^{5,17}. Each case entered using RadPix was additionally coded with the standardized anatomic and pathologic categories according to the Radiologic Lexicon (RadLex) schema¹⁸⁻²¹. Anatomic sites selected from drop-down menus within RadPix and RadLex categories

were automatically added to the Anatomy field of the Indexed Content section for these cases in a hierarchical format, for example:

```
NervousSystem\Head\baseofskull
NervousSystem\Hypothalamus\Infundibulum
NervousSystem\Hypothalamus\Neurohypophysis
```

The choice of whether to use RadPix or the MIRC case entry tool was left to each individual. Access to RadPix was limited due to a limited number of licenses and inability to install the software on our institutional computers. The majority of cases were entered using the built-in MIRC case entry tool. To ease the learning curve involved with entering cases using the built-in MIRC case authoring tool, a detailed Case Entry Guide was distributed electronically via e-mail and in print form to all users. This guide is included in the [Electronic supplementary material](#). A page from a sample case is shown in Fig. 1.

Study images were exported from Synapse (FujiFilm Medical Systems, Chicago, IL, USA) PACS (Picture Archiving and Communication System) stations to bitmap (BMP) format and externally converted to JPG using FastStone Image Viewer v. 2.5 (FastStone Software, Calgary, AB, Canada)²². A minority of cases included image annotations, in part due to the difficulty of entering annotations using the built-in MIRC annotation tool for the average user, and due to the need to install the JAI software on each computer where annotations were to be entered. Prior to entering images into the database, all identifiable patient information was stripped from both images and text. Final authored cases were to be reviewed by resident authors in conjunction with a faculty member to verify accuracy and completeness, although this review was not universal, largely due to resident and faculty time constraints. Cases within the MIRC database were not made available outside our institution via the Publish function in MIRC due to the lack of a reliable internal peer review system.

REPORT GENERATION AND DISTRIBUTION

A manual procedure was used to generate regular tallies of the content of the MIRC database

Fig 1. A sample case from the MIRC teaching file from a patient newly diagnosed with Fabry disease. This case was coded as "ED:A" (Central Nervous System, Other).

for distribution to residents and attending physicians, a flowchart of which is shown in Fig. 2. To accomplish this task, a fresh data file was generated by visiting the administration MIRC page and issuing an inline *save* command as follows:

`http://mircsite:8080/BMC-MIRC/admin?save`

where *<mircsite>* represents the address of the MIRC installation. This file can also be generated directly via a button on the administrative panel. This command generates a *saved-index-file.xml* file on the server. The *saved-index-file.xml* file is stored in the site-specific *webapps* subdirectory on the server, which in this case was */Library/Tomcat/apache-tomcat-5.5.12/webapps/BMC-MIRC/*. The

saved-index-file.xml file was then downloaded and processed with the TestXSLT program (Marc Liyanage Software, Zürich, Switzerland).

The TestXSLT program was used to convert the format of the input XML (Extensible Markup Language) file to an output XML file via the XSLT component of XSL (a style sheet language for XML)^{23–25}.

The resulting XML file was further processed to collapse the data, select only those fields used in coding each case, and output the results to a tab-delimited file using the DataMorph program (Qoppa Software, Atlanta, GA, USA) running on a Windows XP (Microsoft, Redmond, WA, USA) desktop computer (eMachines, Irvine, CA, USA). The resulting file still contained *<code>* and *</code>* XML delimiters which were removed using

Fig 2. Data analysis flowchart. The MIRC index file is parsed through multiple programs on Windows and Mac platforms (see legend), resulting in a text file containing a tally of the number of cases authored for each ASER-based curriculum code.

Microsoft Word (Microsoft) and the result saved as a simple text file.

Next, a static file containing a list of all possible case codes and their corresponding diagnoses was appended to the processed data file for the purpose of filling in the gaps where case types were missing; total case counts for each category were later

decremented by one to account for this. Without this step, categories for which no cases had been entered would be excluded from the report.

A diagnosis code frequency table was then generated using a string of piped command line text utilities in Mac OS X Darwin (Apple Computers), as follows:

```
cat DataMorph_output_file.txt | tr '[a-z]' '[A-Z]' | tr ',' ' ' | tr '\r' '\n'
| tr '\t' ' ' | tr '\n' '\n' | sed '/^$/d' | sort -d | uniq -c | sort -nr | grep
"ED : " | tr '\t' ' ' > output.txt
```

Breaking down this “word histogram” function²⁶, the output of the DataMorph manipulation is sent through the *tr* command (translate; translates the first argument to the second argument using regular expressions) to capitalize all characters in the file. Next, all commas are removed and *<return>* characters are replaced with *<new line>* characters. Tabs are replaced with spaces and *<new line>* characters are added to the appropriate places in the file. The *sed* (stream editor) command line program is used to remove blank lines. Finally, unique words (diagnosis codes) are identified and counted via the *uniq* command, the results sorted via *sort*, and the lines containing valid diagnostic codes identified and displayed using *grep*. Tabs are then added and the stream output directed to a data file. The “|” vertical bar pipe command sends the output of the preceding command into the following one. A flow chart of this process is shown in Fig. 2. Additional manipulations and formatting of this output file were performed after import into Microsoft Excel (Microsoft), including aggregation of multiple disease codes into appropriate departmental subdivisions.

Reports were then distributed to resident and attending physicians in the department in Portable Document Format (PDF; Adobe Systems, San Jose, CA, USA) via e-mail. Subsets of this report were printed and posted in the reading areas for each subsection of the department for additional exposure and accessibility. Paper copies were also distributed directly to subsection Chiefs where particularly large percentages of categories were underrepresented in the database. A complete sample report is included in the [Electronic supplementary material](#).

RESULTS

Prior to the adoption of an organized, focused curriculum to guide case identification, case entry by residents was at best approximately five to ten cases per month, with only three residents regularly participating in any given month (out of a total of 15 radiology residents) and two faculty members (of a total of 25). The distribution of cases within the MIRC database was initially skewed toward common cases such as acute appendicitis and pulmonary embolism. Less common diseases were only haphazardly represented. Most residents and faculty had private collections of interesting cases, which were often only identified by patient and were not organized into coherent teaching file cases.

Within approximately 4 months, 454 total cases had been entered into the MIRC database, occupying 737 Megabytes (MB) of hard drive space, an average of 1.7 MB per case. Typical Joint Photographic Experts Group (JPG; JPEG) images were 512×512 pixels (100 Kilobytes [KB]) for CT images, but could be up to 3,000×3,000 pixels (380 KB) for scanned radiographs. Overall, 42% of the subcategories within the modified ASER curriculum were represented (161 out of 376), although this is an underestimation because “Other” subcategories are included in the denominator of this calculation.

The amount of textual information included in each case was variable, ranging from no text to extensive topic reviews comparable to case reports. The majority of cases contained sufficient textual information to allow the cases to be used for teaching purposes, i.e., history, diagnosis, and

a brief discussion of the topic. Residents often entered case “skeletons” and returned later to fill in details on the topic. The time required to author a case was quite variable; depending on how familiar the author was with the MIRC case entry system, the complexity of the case, and the extent of the case write-up. Cases were frequently entered in multiple stages, beginning with entry of only a case skeleton, often performed by an assistant, followed by later entry of more detailed information. The overall time to author a case ranged from approximately 15 min to 1 h. One of the biggest factors increasing the time to author a case was the need to retrieve and scan hardcopy films. The largest factors in decreasing case authoring time were the availability of an assistant and having case images available in digital format on PACS.

With the introduction of the focused ASER curriculum and distribution of regular reports on the contents of the teaching file, physicians were much more likely to contribute cases. Within several months of establishing the described system, 100% of residents and approximately 40% of faculty (ten total) had contributed cases, with the number of participating residents and faculty steadily increasing over time. Case entry increased from approximately 3.3 cases per month per resident (ten cases/month/three residents) to 7.5 (454 cases/4 months/15 residents), so that both the number of residents participating and their individual productivity increased over this period (Fig. 3). The number of cases per month per faculty member increased from approximately 5 per month (ten cases/month/two faculty) up to 11.4 per month (454 cases/4 months/ten faculty).

Residents stated anecdotally that, while they referred to the case tallies distributed weekly via e-mail, the physical hardcopy was frequently used for noting information on cases missing from the list during the course of their clinical duties. Entering several cases at once after formal work hours using the printed case tallies with accumulated notes was found to be generally more efficient than attempting to author teaching file cases between clinical duties. Mid-level residents (R2 and R3 levels) had greater participation than junior or senior residents, possibly because junior residents were still becoming oriented and had not yet covered the emergency department to a significant degree and senior residents had completed the majority of their call shifts and

Fig 3. Cases authored by all residents per week (a) and per month (b). The ASER-based curriculum was adopted on week 8. A large increase in new case entry occurred immediately following introduction of the curriculum, with the greatest rate of case entry occurring in month 4. The rate of case entry diminished somewhat after this point, but remained markedly increased over the initial rate.

emergency coverage (Fig. 4) and were more focused on preparation for Boards.

Non-emergency cases entered into the MIRC database at the time of this study also modestly increased to approximately 15 cases per month, the majority of which originated from the largest contributors to the ASER-identified case categories. Thus, there was a small collateral increase in unrelated case entry simply due to participation in a more coordinated but topically unrelated departmental effort. As cases were entered, case authors routinely used the MIRC database to generate case conferences and to individually show other residents interesting cases.

Representative cases within subspecialties of the emergency radiology curriculum were not auth-

Fig 4. Total cases authored by residents in each Program Year (PGY) after adoption of the ASER-based curriculum. Values are averages ($\pm$ standard error of the mean [SEM]). Mid-level residents (PGY3) were by far the greatest contributors during this period.

ored homogeneously, with a greater number of cases entered for neuroradiology and abdominal imaging compared to pediatric and obstetric/gynecologic imaging, for example (see Table 1). The reasons for this were multifactorial, with the biggest issues being the differential caseload and variety seen in the better represented subspecialties at our institution and the varying degrees to which faculty in each subspecialty contributed cases. Cases containing information not natively in digital format (e.g., plain films) were also somewhat underrepresented, likely because entry of these cases required the additional step of retrieving and digitizing the images.

The roadblocks typically associated with generating MIRC teaching file cases remained, including difficulty in transferring digital images from PACS, scanning hardcopy films, and assembling history and other pertinent case information from the electronic and paper medical records. No infrastructure modifications were made to deal specifically with these issues; however, the knowledge of those most active in case generation regarding how to best overcome them were more widely disseminated to newer contributors. Those most adept at entering cases using the MIRC built-in editor frequently entered cases for other case authors to speed the process.

Cases entered using the RadPix software package had more numerous and higher quality image

annotations and generally contained greater textual content, perhaps due to greater ease of data entry. Relatively few videos were included in the database due to limitations in the MIRC authoring software. All cases that included video content were generated using RadPix. Prior to final acceptance, staff approval of each case was required. Ideally, an independent physician would also review the case, providing internal peer review, although this has been difficult to coordinate.

Finally, another measure of the success of such a teaching aid is the degree to which it has been used for pedagogy. Although difficult to quantify, resident authors did frequently rely on the MIRC database to find cases for a weekly case conference. Anecdotally, assembling the information needed for these conferences was greatly facilitated by being able to search the assembled database. Although the MIRC system can be used for presentation purposes, residents almost uniformly chose to export information within the database to PowerPoint (Microsoft) for final presentation using the MIRC2PPT program available via MyPACS (McKesson Corporation, San Francisco, CA, USA)²⁷.

DISCUSSION

The inclusion of the comprehensive American Society of Emergency Radiology (ASER) curriculum to help guide case identification, entry, tracking, and reporting resulted in significantly

Table 1. Percentage of subcategories within each category of the ASER-based curriculum ultimately represented within the database

Category	Degree of completeness (%)
Central nervous system	75
Head and neck	82
Cervical spine	52
Cardiovascular	53
Chest	56
Abdomen	73
Obstetrics/gynecology	27
Male genitourinary	36
Upper extremity	33
Pelvis/hip	86
Lower extremity	40
Pediatric	19

increased participation by radiology residents and faculty and a broader collection of cases within the database. Within a month of initiating this focused approach, nearly all radiology residents were participating to varying degrees. Interest in adding missing cases to the repository increased substantially at the time case tallies were distributed to residents and section Chiefs. Interaction with the section Chiefs during the distribution of these periodic reports had the added effect of reinforcing their participation in the building of the overall teaching file.

Upon review of the list of needed cases, individual attending physicians were often able to recall cases from their own hardcopy or digital teaching files for inclusion in the central MIRC system, accomplishing the dual goals of digitizing and cataloguing their dispersed teaching files and filling in missing cases within the ASER curriculum. Residents who were most active in the project also became contacts for faculty, who often passed on their own interesting cases to these residents for entry into MIRC, providing additional educational opportunities.

Rather than slowing down case entry by adding an additional layer to an already cumbersome process, the adoption of a standardized framework to use as a catalogue for identifying cases for entry into the teaching file actually facilitated the overall process. A component of this success is likely that relatively few technically adept individuals in the department handled the brunt of the behind-the-scenes requirements to install and maintain the teaching file and generate weekly reports. Another factor was the availability of an assistant to enter basic case skeletons upon which case authors could later build. Aside from the use of the curriculum framework, the presence of the study itself and the resources allocated to it likely had some effect in terms of galvanizing faculty efforts to recruit more participants for the general teaching file program. Without these additional resources, the progress in participation ascribed to the ASER-based curriculum would likely have been less.

The small increase in the entry of non-ASER cases may be related to individuals' subjectively increased awareness of the presence of the MIRC teaching file among both residents and faculty, presence of a more coordinated means by which to disseminate instructions on how to access the database, and a "critical mass" effect whereby enough people were involved in a unified effort

that other physicians felt compelled to contribute their own cases, whether they were specifically related to the ASER curriculum or not.

One limitation frequently encountered was the difficulty of entering cases into the MIRC system. While the web-based case entry system built into MIRC is quite functional, many users had significant difficulty successfully entering cases. The departmental PACS was not directly attached to the MIRC server, necessitating the manual capture, conversion, and transfer of images. The learning curve for MIRC case assembly and entry was significant enough that very few attending physicians ultimately felt comfortable entering cases on their own without resident assistance.

These limitations led to most cases being entered by residents, whether they were the ones to identify the case or not. An unintended consequence of this arrangement was that residents who were more adept at entering cases saw many more of these interesting cases as a result, as these were filtered through them for processing. The use of RadPix as a client-side stand-alone case entry tool helped overcome this limitation to some degree; however, its limited availability curtailed its impact.

One of the greatest challenges to the adoption of a MIRC-based digital teaching file system once case entry difficulties are overcome is the maintenance over time. Residents and faculty have limited time and expertise to continually verify the integrity of the database, test backups, and monitor security issues; a dedicated staff person may ultimately better accomplish these tasks. The time needed to collect information and author cases, peer review authored cases, and ensure currency of the database represents an additional burden.

Another limitation encountered in the context of this project was in the generation of reports from the content of the MIRC database. While the database was well organized internally, there was no straightforward way to mine the data contained therein. The information held on the MIRC host could be accessed and tabulated, but the procedure was not straightforward and required the use of multiple programs and relatively sophisticated techniques on two computing platforms. A simpler way of accessing and analyzing the information stored in MIRC sites would be beneficial for research and teaching purposes.

With the availability of information on a global scale, radiologists have the opportunity to train by

reviewing cases from many previously unavailable resources. This capability allows cases involving geographically localized diseases to be disseminated widely, improving medical education. A digital teaching file system with the built-in capability to transfer information on the Internet, such as the RSNA MIRC system, is a natural tool to aid in distribution of this specialized information.

CONCLUSIONS

The inclusion of a comprehensive, tabulated curriculum for a specific subfield of radiology did enhance the orderly population of a MIRC-based digital teaching file. Resident and faculty interest and participation increased substantially relative to the initial situation where individuals simply identified interesting cases haphazardly and logged them without communication or guidance into their own non-standard disconnected teaching file systems. Such an approach may prove beneficial for other programs as teaching files are implemented or augmented.

Some hindrances were encountered in using the MIRC system, primarily involving the entry of cases and the analysis of the contents of the database. These limitations were ultimately overcome, but may be points to consider for radiology departments implementing such a system. In particular, an external tool such as RadPix should be considered to ease case entry. The degree of technical facility required to maintain such a system likely necessitates strong Information Technology support for sustainability.

Incorporation of other established subspecialty radiology training curricula is needed to determine if these findings are valid for other subspecialties and what curriculum format might be most effective in driving physician participation and digital teaching file case entry. Additional investigation is also needed to determine how participation and case identification and entry rates vary with the number of subspecialties and case categories presented to radiologists and if a saturation point exists where efficiency might plateau or decrease.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Dr. J. Robert Kirkwood, MD, FACR for his support of this project. We also thank the

many residents and faculty members who contributed cases to the database and Ms. Lindsay Coughlin for data input and case management. We thank the MIRC community on the RSNA MIRC users' forums and John Perry and Drs. William Weadock and Trongtum Tongdee in particular for useful conversations and suggestions. We also thank Ms. Sharon Wayne for proofreading the manuscript.

Competing interests The authors state that they have no competing interests.

Authors' contributions FJW developed the project, installed the necessary software, analyzed the data, entered cases into the database, and wrote and reviewed the manuscript.

SK entered cases into the database, participated in coordination of the project, and reviewed and edited the final manuscript.

DD entered cases into the database, participated in coordination of the project, and reviewed and edited the final manuscript.

SOC contributed to the conceptual development of the project, case entry, coordination of the project, faculty and resident recruitment, and reviewed and edited the final manuscript.

BC contributed to the conceptual development of the project, case identification, faculty and resident recruitment, and reviewed and edited the final manuscript.

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