Review Article

Singapore National Medical Image Resource Centre (SN.MIRC): A World Wide Web Resource for Radiology Education

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Abstract

Radiology education is heavily dependent on visual images, and case-based teaching files comprising medical images can be an important tool for teaching diagnostic radiology. Currently, hardcopy film is being rapidly replaced by digital radiological images in teaching hospitals, and an electronic teaching file (ETF) library would be desirable. Furthermore, a repository of ETFs deployed on the World Wide Web has the potential for e-learning applications to benefit a larger community of learners. In this paper, we describe a Singapore National Medical Image Resource Centre (SN.MIRC) that can serve as a World Wide Web resource for teaching diagnostic radiology. On SN.MIRC, ETFs can be created using a variety of mechanisms including file upload and online form-filling, and users can search for cases using the Medical Image Resource Center (MIRC) query schema developed by the Radiological Society of North America (RSNA). The system can be improved with future enhancements, including multimedia interactive teaching files and distance learning for continuing professional development. However, significant challenges exist when exploring the potential of using the World Wide Web for radiology education.

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Introduction

Case-based Teaching Files

Radiological images are critical for diagnosis, teaching and research. In radiology education, learners must be exposed to large amounts of visual information, and assimilation of these medical images is essential in the training of diagnostic skills. Case-based radiology teaching files, including radiological images and information about clinical presentation, disease diagnosis or imaging technique, are an important component of radiology teaching. From small personal collections of "interesting cases" to hospital libraries of indexed repositories, medical and radiological images are currently used for radiology education and have the potential for additional benefits, especially if they are in the digital realm.

The existing teaching film library in most hospitals typically comprises a file collection of interesting cases based on paper and film.[1] However, these hardcopy film libraries are prone to physical deterioration, obsolescence, and are limited in their user interactivity. Furthermore, as more radiology departments move to the digital picture archive and communication system (PACS) environment, hardcopy film libraries will become obsolete. However, although there is great potential for PACS images to be integrated into a digital library of electronic teaching files (ETFs), efforts to do so have been hampered by the lack of commercially available educational and research tools in clinical PACS.[2]

PACS and MIRC

To overcome these hurdles to radiology education, we previously developed Medical Image Repository Interfaced with PACS (MIRIP), a method to create ETFs using PACS images.[3,4] MIRIP comprises a computer server that stores and catalogues a collection of ETFs created using hospital PACS. These ETFs can be sorted, searched, and accessed by multiple simultaneous users (Fig. 1). Based on java

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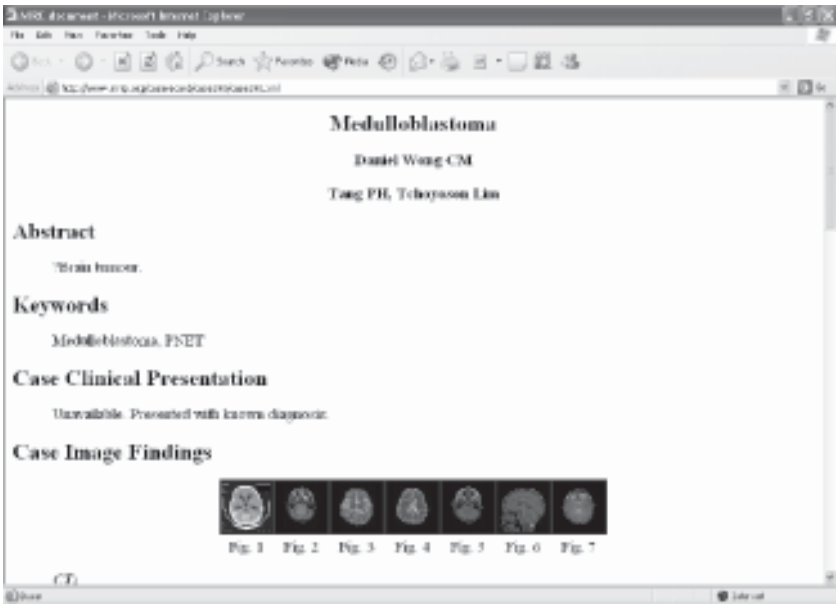

Fig. 1. An electronic teaching file (ETF) created using radiological images of a real patient from picture archive and communication system (PACS), illustrating a teaching point. Screen capture showing computed tomography and magnetic resonance images of a case of medulloblastoma.

programming language and web protocols, it features a suite of user-friendly and intuitive image manipulation tools, disease index, and patient anonymisation. The MIRIP system also conforms to the Medical Imaging Resource Center (MIRC), which was developed in 2001 by the Radiological Society of North America (RSNA) as a common platform for exchanging ETFs and research datasets.[5]

The MIRIP project arose initially out of the need for post-graduate and continuing medical education (CME) in a clinical radiology department. Due to manpower constraints and busy scheduling, tutors were not available for teaching during certain times or when post-graduate trainees were free for educational activities. In order to address the lack of a hardcopy film library, and to facilitate learner-selected timing and control of educational activities, a digital library of ETFs that is always online and can support multiple users on the hospital intranet would be useful. To date, MIRIP has been deployed within the intranet of several local and overseas hospitals to function as a radiology departmental teaching asset. With the establishment of the RSNA MIRC, there is potential for radiology ETF to be positioned on the World Wide Web instead of being confined to the intranet of individual hospitals. A modified version of MIRIP can be developed to fulfill the needs of national radiology education.

Medical Education on the World Wide Web

The World Wide Web is a rich source of information and can be harnessed for medical education.[6] Specifically, digital radiology ETF is a logical choice for presentation in the environment of the World Wide Web. Furthermore, web-based learning is attractive as it is widely available, inexpensive, accessible at any time, and can be easily updated. The growing popularity and increasing importance of the World Wide Web for medical education is part of a multidisciplinary and worldwide trend towards web-based resources for the public (information, support groups) and medical professionals (electronic medical journals). Many non-medical education institutions already have e-learning initiatives deployed either within campus intranets or on the World Wide Web.

On the other hand, not everything on the World Wide Web is useful, accurate, or beneficial. The quality and veracity of medical information on the World Wide Web is variable and much time can be wasted as many websites do not meet basic publication standards.[7] High-quality radiology websites and portals include prestigious radiological societies such as the Radiological Society of North America (RSNA)[8] or the European Association of Radiology,[9] and private companies such as Aunt Minnie.[10] Currently, useful websites for radiology education include ETF resources that may feature a searchable database of cases (by disease, keyword, etc), or, alternatively, cases that can be viewed as "unknowns" without the diagnosis being revealed. This feature is particularly popular with trainees preparing for certification examinations.[11]

Singapore National MIRC

Singapore enjoys the advantages of a highly literate and educated population, and is well-served by widely available (and on the whole affordable) internet connectivity. Furthermore, physicians have been exposed to electronic clinical systems, particularly in recent years, when electronic medical record initiatives have been widely deployed in the restructured hospitals.[12] However, much of this activity has

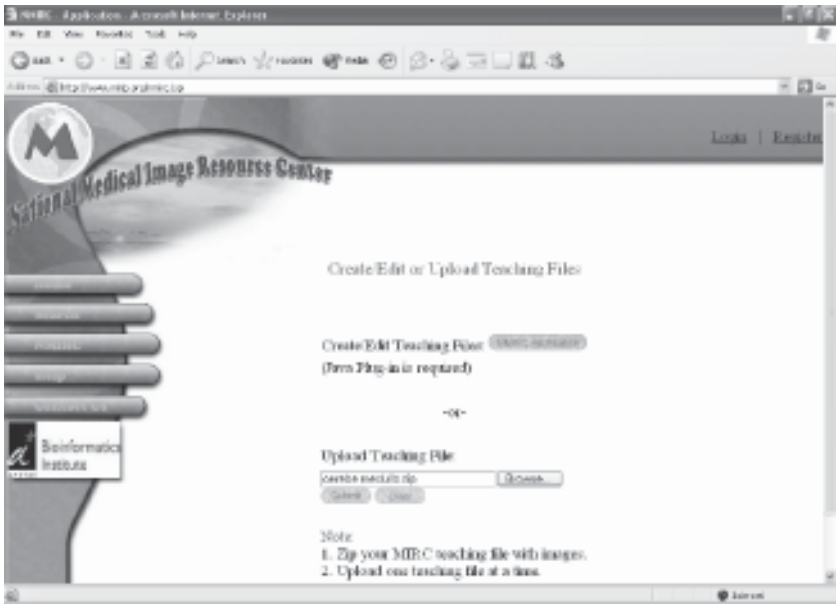

Fig. 2. Screen capture of the Singapore National Medical Image Resource Centre (SN-MIRC) showing alternative methods of submitting ETF: either using the online authoring tool ("NMIRC Application", see Figure 3) or uploading a "zip" document (such as an ETF created from PACS).

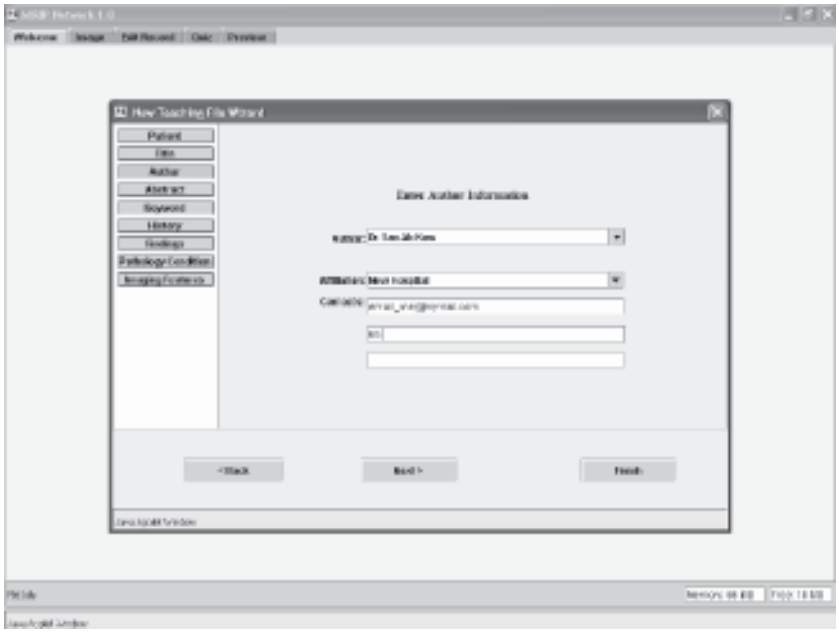

Fig. 3. Screen capture of the online authoring tool that can be used to create a teaching file by direct data entry.

focused on the immediate benefits of clinical utility and patient safety, and has not specifically addressed medical teaching or research. Recently, there have been local groups that have actively studied electronic delivery of medical education, and some tools have been developed.[13-15]

In order to explore radiology education on the World Wide Web, we have drawn on our previous experience and modified our computer systems and software to set up a national medical image initiative. This comprises an open portal on the World Wide Web including a server that can receive MIRC-compliant ETF contributions from registered users. On this website, MIRC-compliant ETFs can be uploaded (Fig. 2). These files may be created either using the MIRIP system (e.g., in large teaching hospitals utilising PACS images) or MIRIP-Personal (a stand-alone software programme developed to allow individuals to maintain their own private image collection without the need for PACS images).[16] The choice of using two different methods of creating ETF enables a broad spectrum of radiologists, including academicians from large teaching hospitals as well as individuals in private practice, to participate in Singapore National MIRC. This has potential educational benefits for the wider community of radiologists.[17]

In addition to allowing ready-made MIRC-compliant ETFs to be uploaded onto the website, a step-by-step data entry mechanism was also created to allow users to create

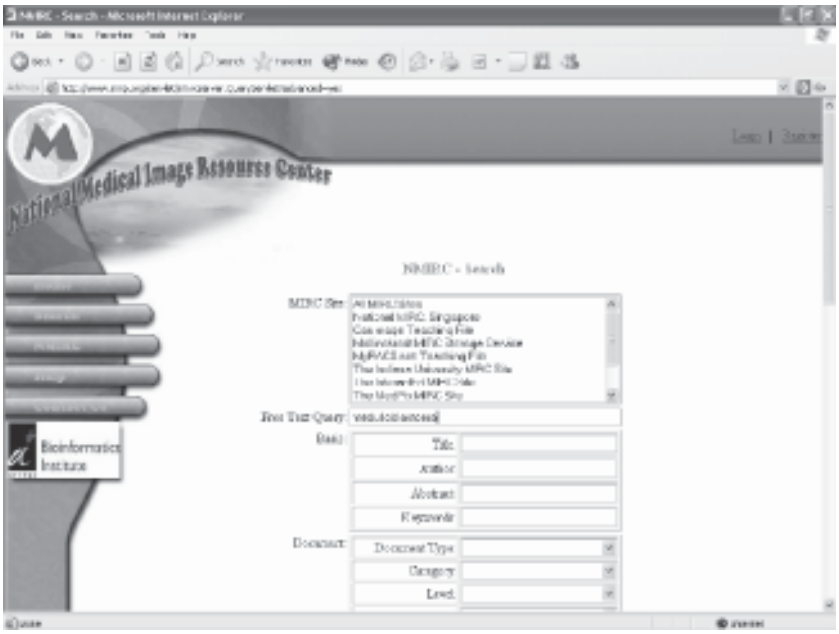

Fig. 4. Users can search the Singapore National Medical Image Resourc Centre (SN-MIRC) for ETF conforming to a free text (or other) criteria, in this example, for "medulloblastoma", which would return the teaching file in Figure 1.

ETFs "on the fly" by filling in appropriate form fields such as author information, abstract, history, findings, and diagnosis (Fig. 3). By providing an online authoring mechanism, the portal effectively allows any radiologist or physician from any country to contribute and participate in the Singapore National MIRC.

The ETFs contributed by users of the Singapore National MIRC can then be viewed using the "search" function based on the Query service of MIRC protocols. In the Query service, all the linked MIRC "storage" websites for medical images (such as the Singapore National MIRC), can be interrogated for either specific words in specified data fields or free text (example: search for "medulloblastoma" in Figure 4). The storage service will then respond and return links to matching ETFs, and the search results (example: all ETFs with the free text "medulloblastoma" as in Figure 1) can be displayed. Initially, proof of concept was carried out using neuroradiology ETFs from a single hospital (National Neuroscience Institute). This was successful and a full functional version has been deployed on the World Wide Web and the Singapore National MIRC has been successfully linked to the RSNA MIRC portal, joining a number of international hospitals and internet-based teaching file websites currently linked to MIRC.

Challenges, Limitations and Possibilities

Although the Singapore National MIRC online ETF repository is able to accept images from various sources, including an endless supply of radiological images with teaching value from real-time clinical PACS, the entire endeavour still requires input from content providers with specialised domain knowledge. Hence, the viability and usability of the project is dependent on physicians providing the necessary input, and significant challenges exist in sustaining this input. One possible solution would be to make ETFs part of the credit requirement in existing educational programmes such as Basic or Advanced Specialty training in Diagnostic Radiology. Collaboration with the local Specialty Training Committees, the College of Radiologists of the Academy of Medicine, Singapore and the Singapore Radiological Society would be essential to ensure continuing support and quality assurance. Copyright ownership, patient privacy and data integrity issues will also need to be addressed.

The possibility of adapting image-intensive digital teaching files outside of radiological pictures can also be explored. Digital e-learning favours many highly visual medical disciplines such as ophthalmology, pathology and dermatology, and various non-radiological picture formats can be incorporated into existing software systems (Unpublished data—Yang et al).

One useful and direct application of the image repository would be to use it for continuing professional development (CPD) and CME. Currently, distance learning initiatives (Category 3B in the Singapore Medical Council CME programme)[18] comprise a series of questions based on designated course material (for instance, an article in a medical journal). With minimal additional effort, the contents of an ETF or a cluster of ETFs can be adapted to become course material for electronic distance learning and self-test questions can be produced that can be accredited for CME. This will have the advantage of making use of locally created material without the drawback of cost and

intellectual property issues inherent in using copyrighted material from other sources. In order to build up a distance learning programme, content must be developed in combination with a secure learning management system that can database and track credits for successful users, such as that provided by the Academy of Medicine, Singapore.

Another possible adaptation and improvement of ETF is in the creation of multimedia teaching files (MMTF). Using a newly developed software encoding process, existing static radiology image files (such as from ETFs) can be enhanced with spoken explanation and video manipulation of the radiological images for didactic teaching purposes.[19] Image annotations including text, line drawings, and highlights can be recorded in a similar manner to a transparent overlay to demonstrate the process of image interpretation and to illustrate the relevant abnormalities in the MMTF (Fig. 5). Deployed online on the World Wide Web, this has the potential to function as discussion threads as well as explore the concept of remote consultation and virtual viva voce professional examination.[20,21] The interactivity of MMTF has the potential to enhance the learning process and enable a richer experience for both teacher and student.

However, even with interactive and multimedia support, radiology education is far from completely addressed by electronic learning. An essential part of radiology practice comprises hands-on procedural skills, such as probe placement in ultrasonography, catheter manipulation in X-ray angiography, and conducting multidisciplinary team conferences. These are difficult to teach without real-life interactions with patients and colleagues in the time-honoured apprenticeship methods now in place. Furthermore, interventional radiology stands as a rather special entity more akin to a combination of minimally invasive surgery, albeit driven by image interpretation. Procedures such as angioplasty, and deployment of stents, filters, balloons, etc, require a unique skillset that combines judgement, experience and knowledge of medical materials, and goes beyond merely using procedural aids to diagnosis. These challenges in radiology education are considerable, but they are being explored in various e-learning programmes, including the Radiological Integrated Training Initiative (RITI) of the Royal College of Radiologists.[22]

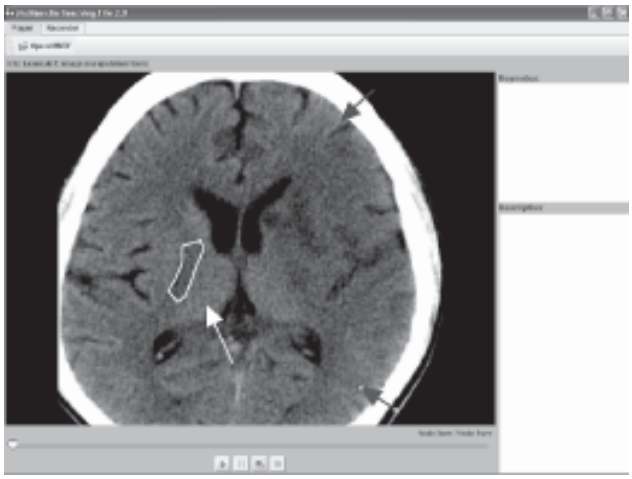

Fig. 5. Screen capture of a multimedia teaching file (MMTF) showing a patient with left middle cerebral artery territory infarction. Authors of these teaching files can illustrate the features and the process of diagnosis using line drawings, arrows, text and audio commentary.

Finally, although web-based education is highly attractive and has an important role as an adjunct to conventional teaching methods, it cannot replace the vital human element in medical education.[23] The non-interpretive skills of radiology[24] are as important, if not more important, than cognitive knowledge, and the "informal curriculum" and social aspects of learning cannot be easily duplicated online.[25] The importance of role models[26] and mentoring programmes cannot be over-emphasized, especially in light of recent events highlighting the essential qualities of professional conduct and medical ethics.

Conclusion

Medical education in the twenty-first century can benefit greatly from computerisation and digitisation, especially in an image-intensive specialty such as diagnostic radiology. An online repository of radiological images in the form of ETFs would be an important development in achieving the goal of harnessing technology for clinical service, education and research. The SN.MIRC represents a tentative first step forward, but will require the concerted efforts of the radiology community; it is only part of a wider effort towards a more holistic approach to radiology education.

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REFERENCES

1. Markivee CR. Automated filing of "teaching" radiographs under the ACR Index of Roentgen Diagnosis. AJR Am J Roentgenol 1990;154:659.
2. Siegel E, Reiner B. Electronic teaching files: seven-year experience using a commercial picture archiving and communication system. J Digit Imaging 2001;14 (Suppl):125-7.
3. Lim CCT, Yang GL, Tan JT, Badion LM, Nowinski WL, Hui F. MIRIP (Medical Image Repository Interface with PACS): a Neuroradiology MIRC Database. Proceedings of the 88th Scientific Assembly & Annual Meeting; Chicago. Radiological Society of North America, 2002.
4. Lim CC, Yang GL, Nowinski WL, Hui F. Medical Image Resource Center – making electronic teaching files from PACS. J Digit Imaging 2003;16:331-6.

5. MIRC committee publications. Radiological Society of North America (RSNA). Available at: http://mirc.rsna.org/. Accessed 25 February 2006.
6. Gotwald TF, Daniaux M, Stoeger A, Knapp R, zur Nedden D. The value of the World Wide Web for tele-education in radiology. J Telemed Telecare 2000;6:27-30.
7. Scarsbrook AF, Graham RN, Perriss RW. The scope of educational resources for radiologists on the internet. Clin Radiol 2005;60:524-30.
8. RSNA Link. Radiological Society of North America (RSNA). Available at: www.rsna.org/education/related/index.html. Accessed 25 February 2006.
9. Euro Rad. European Association of Radiology e-learning Initiative. Available at: www.eurorad.org/. Accessed 25 February 2006.
10. Aunt Minnie 2006 Feb 25. Available at: www.auntminnie.com/. Accessed 25 February 2006.
11. Scarsbrook AF, Foley PT, Perriss RW, Graham RN. Radiological digital teaching file development: an overview. Clin Radiol 2005;60:831-7.
12. Ong BK. Leveraging on information technology to enhance patient care: a doctor's perspective of implementation in a Singapore academic hospital. Ann Acad Med Singapore 2002;31:707-11.
13. Goh PS, Wang SC, Low A, Lee KH, Lim L. New paradigm in teaching radiology – asynchronous/synchronous blended web-based teaching techniques. Proceedings of 1st Asia Pacific Conference on Medical Education; Singapore. National University of Singapore, 2003.
14. Goh PS, Wang SC, Low A, Lew KH, Lim L. Use of a web-based eCourseware to facilitate face-to-face teaching. Proceedings of the Annual Conference 2004; Edinburgh. Association for Medical Education in Europe, 2004.
15. Low A, Goh PS, Wang SC, Lew KH, Lim L. Efficacy of eCourseware in teaching radiology. Proceedings of the International Conference on Teaching and Learning in Higher Education; Singapore. National University of Singapore, 2004
16. Yang GL, Lim TCC, Narayanaswami B, Hui F, Nowinski WL. MIRP Authoring Tool – Make your own MIRC teaching files. Proceedings of the 89th Scientific Assembly & Annual Meeting; Chicago. Radiological Society of North America, 2003.
17. Yang GL, Lim TCC, Xu MS, Narayanaswami B, Nowinski WL, Hui F. National MIRC Server on the World Wide Web. Proceedings of the 90th Scientific Assembly & Annual Meeting; Chicago. Radiological Society of North America, 2004.
18. Singapore Medical Council. FAQs for compulsory CME. Available at: www.eurorad.orgsmc.gov.sg/. Accessed 25 February 2006.
19. Yang GL, Aziz A, Narayanaswami B, Anand A, Lim CC, Nowinski WL. Informatics in radiology (infoRAD): multimedia extension of medical imaging resource center teaching files. Radiographics 2005;25:1699-708.
20. Narayanaswami B, Aziz A, Yang G, Anand A, Lim TC, Nowinski WL. Multi-media-based medical image discussion forum. Proceedings of the 91st Scientific Assembly & Annual Meeting; Chicago. Radiological Society of North America, 2005.
21. Narayanaswami B, Aziz A, Yang G, Anand A, Lim TC, Nowinski WL. Web-based interactive radiology examination system. Proceedings of the 91st Scientific Assembly & Annual Meeting; Chicago. Radiological Society of North America, 2005.
22. Royal College of Radiologists. Radiology Integrated Training Initiative. Available at: www.riti.org.uk/. Accessed 25 February 2006.
23. Gunderman RB, Kang YP, Fraley RE, Williamson KB. Instructional technology and radiologic education. Radiology 2001;221:1-4.
24. Collins J, Amsel S, Alderson PO. 2001 Joseph E. and Nancy O. Whitley Award. Teaching noninterpretive skills to radiology residents: a collaborative effort between the American College of Radiology and the Association of Program Directors in Radiology. Acad Radiol 2001;8: 903-7.
25. Hafferty FW. Beyond curriculum reform: confronting medicine's hidden curriculum. Acad Med 1998;73:403-7.
26. Gunderman RB. Role models in the education of radiologists. AJR Am J Roentgenol 2002;179:327-9.