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PACS: A Guide to the Digital Revolution

Book Review

PACS: A Guide to the Digital Revolution

Keith J. Dreyer, Amit Mehta, and James H. Thrall. New York, NY: Springer-Verlag; 2002. 435 pages. $95.

This multi-authored book covers the major topics in picture archiving and communication systems (PACS) and provides valuable information in understanding the technologic advancements that have resulted in the digital revolution in the practice of radiology. The thorough and comprehensive analysis of the various PACS concepts and their relationships in forming the digital radiology department in an integrated health care enterprise makes this book a valuable tool for radiologists, computer scientists, administrators, and technologists in the field.

One of the main features of this book that greatly enhances its teaching value is the abundance of examples explaining and simplifying technical issues that would otherwise seem complicated, such as determining compatibility between two PACS devices on the basis of Digital Imaging and Communications in Medicine (DICOM) standard. The ability to learn through logically designed examples increases the confidence and participation of the reader, who comes to the realization that a degree in computer science is not a prerequisite to relate to some of the most technical aspects of PACS.

The large number of relevant figures and diagrams that illustrate the issues discussed in the text is very effective and enables easier reading and understanding of the material. Ironically, errors found in the legends of some of the figures, particularly in Chapter four, make them awkward and confusing to follow. The strength of the organizational presentation of the material is augmented by the use of tables that organize knowledge and information in a manner that makes it easier to comprehend or reference.

The book is divided into four main categories: 1) Introductory Concepts, 2) Computing Fundamentals, 3) Advanced Imaging Technologies, and 4) Future Opportunities. There are 16 chapters in total, with 18 contributors. For those radiology departments that are developing a request for proposal for PACS, this book can be very helpful, because it analyzes all aspects involved in the process: PACS components and technology, departmental workflow changes, enterprise-wide imaging, financial modeling, legal issues and policies, and research and education.

The chapter on financial modeling describes various methods of financial analysis for all the major cost elements involved in PACS. It highlights a case of financial analysis by using net present value, which is a widely accepted and respected method. This chapter not only explains cost-savings opportunities but also emphasizes that in a health care environment, nonfinancial benefits should be taken into consideration to fully evaluate the investment. The risks of project implementation are considered from the standpoint of technology (integration, network, etc.) and organization (acceptance, realization of savings in personnel and film).

The section on computing fundamentals provides the not-so-computer-skilled reader with some basic computer knowledge by describing the main components and the operation of the personal computer. The usefulness of this chapter is questionable considering that the material is very basic and does not attempt to relate any concepts to PACS. Contrary to what is mentioned in the preface of the book, this chapter does not describe any terminology for digital imaging. I think the value of this chapter, as an introduction to basic computing fundamentals relevant to PACS, could be enhanced by incorporating additional information extracted from other chapters, such as bits, bytes, and pixels (from Chapter 9: Storage and Archives).

Two critical chapters in understanding PACS are networking fundamentals and DICOM. They both do an excellent job in providing the background and knowledge necessary to appreciate the importance of good network design and implementation and the fundamental role of the DICOM standard in providing the necessary interoperability among the various devices (scanners, workstations, printers, etc.). A plethora of examples (including real-world scenarios) and relevant illustrations in both of these chapters help to demystify the technical complexities and preserve the continuous interest of the reader in some of the most intricate aspects of PACS.

The chapter on image acquisition discusses the process of data entry into the PACS through integration of the various modalities. It is critical that this implementation is successful, because errors generated during image acquisition can propagate throughout the system and adversely affect the PACS-based operation. Furthermore, it is explained that integration of PACS with Radiology Information System-Hospital Information System (RIS-HIS) is essential at image acquisition and that DICOM conformance should be required from both modality and PACS vendors. A detailed description is provided regarding how image acquisition is obtained from computed radiography versus digital radiography.

The introduction of PACS should not be thought of as mere computerization of existing processes in radiology but rather as the enabling infrastructure for redesigning and optimizing the entire workflow process (movement of patients, images, and other relevant information). The well-written chapter on image workflow discusses how the "dual mission of radiology" (ie, providing high quality patient care while maintaining cost-effectiveness) can be pursued by im-

proving the workflow of radiologists, technologists, clerical staff, and clinicians on the basis of PACS deployment and RIS-HIS integration. Appropriate use of RIS-HIS-PACS functionality can have a profound impact on ordering studies, generating reports, eliminating films, retrieving old studies, and other processes. Because of the high degree of operational dependence on PACS, the author provides practical advice regarding breakdowns and suggests contingency planning as being absolutely imperative. The future outlook of workflow patterns is also discussed and how the trend toward more intelligent software, computer-assisted diagnosis, and disease- and indication-specific processing will enable PACS to maximize its potential to improve the workflow in radiology.

The easy-to-read chapter on workstations thoroughly covers all aspects related to this fundamental (particularly to the radiologist) component of PACS. An overview of hardware and software and the history of workstations are provided. The role of the workstation, with its advantages over conventional film in the process of diagnostic interpretation, consultation, and teaching, is analyzed. Insight is provided regarding how humans interact with computers and how this applies to PACS workstations, leading to the development of an easy-to-learn and easy-to-use yet fully functional user interface that follows a logical and simple mental model. Another contribution of this chapter is found in the suggestions regarding how to develop a functional specification for a PACS workstation. The suggestions are well organized in tables.

Of utmost importance in a PACS environment is ensuring proper long-term archival of image data. The chapter on storage and archives provides a review of the current storage technologies and examines various archive considerations for PACS, such as cost, capacity, reliability, scalability, and disaster recovery procedures. Of particular interest are future technologies that seem to be promising, such as holographic storage, storage area networks, and the trend toward electronic data vaulting as an emerging strategy that would ensure protection of the data against natural disasters or terrorism.

The explosive growth of data in a PACS environment creates a need and poses a challenge regarding how to manage these enormous volumes in terms of storage and distribution. The chapter on image compression explores the various methodologies of both "lossless" and "lossy" data compression and how they can be applied to PACS. The basics of image compression are explained with the aid of easy-to-follow examples. The encouraging message is that image compression is improving with new efficient algorithms and that its incorporation into the DICOM standard is also evolving. A companion CD mentioned in this chapter was not included and is not referenced elsewhere in the book.

The chapter on voice recognition (VR) describes how this technology facilitates a more efficient practice for radiologists by replacing the conventional approach to dictation that traditionally represented a bottleneck in the process. Hardware and software improvements in VR enable its seamless integration to PACS while increasingly gaining acceptance by radiologists. A real-life example of VR implementation in a hospital is provided that analyzes all the key elements that can make a significant contribution to the success of such a project.

The chapter on enterprise imaging deals with issues associated with the need for hospital-wide image distribution that would enable the delivery of images and other relevant information to the referring physicians. A cost-effective solution can be designed on the basis of Internet technology by using a client-server infrastructure and hospital intranets.

The chapter on teleradiology describes telemedicine in general, and teleradiology in particular, as the availability of radiologic images and other relevant information over a distance by using telecommunication systems. The available enabling technology for image acquisition, transmission of data to remote locations, image viewing on the workstation, and the accuracy involved in digital interpretation are presented. Applications of teleradiology include on-call coverage, second opinion and consultations, primary interpretation for free-standing imaging centers or rural hospitals, "reverse" teleradiology, research, and teaching. Useful implementation tips are provided from real-life experience in practicing teleradiology. Finally, related legal and socioeconomic issues, such as licensure, malpractice, and patient confidentiality, are discussed. The American College of Radiology (ACR) standard for teleradiology is listed in an Appendix.

A book on PACS would not be balanced without describing the current law and policy as it pertains to digital radiology practice. The chapter on legal issues and formal policies, which is extremely interesting to read, states that although some legal issues are well defined, other important aspects have not yet been addressed. One reason is that the pace of technologic innovations found in PACS outperforms the institution of laws and policies to govern its use. The information, although "not a substitute for qualified legal advice," educates the radiologist on the standards and policies of professional organizations such as the American College of Radiology and the American Medical Association as well as official government regulations (Food and Drug Administration, Health Care Financing Administration [now called the *Centers for Medicare & Medicaid Services*]). Other related legal considerations include medical malpractice, insurance issues, and record keeping.

Because teaching and research in radiology are largely image based, the chapter on research and education examines the impact of digital technology in an academic department. The PACS infrastructure can facilitate the development of computer-based imaging research and educational projects, but some challenges, such as migrating data and authoring tools, still need to be addressed. Teaching and research applications include the creation of teaching

files, folders with interesting, conferencing, consultation, search information engines and other.

The final chapter on medical utilization and management contains very interesting and significant information regarding how the appropriateness criteria for radiology studies can lead to an increasing importance of radiology in evaluating patients and how more use of radiology can save money in other parts of the system (eg, from unnecessary surgery). Although this chapter presents an important subject, the text fails to provide a linkage with PACS and digital radiology, diminishing the chapter's effectiveness. There could be, for example, an effort to elaborate on how PACS technology could enable the collection and analysis of data from ordering physicians, or how ignorance in ordering radiology studies could be addressed, or how PACS could contribute to proper use of radiology that would lead to decreased cost and increased quality.

The book provides references to literature and web links for readers who are interested in a more in-depth treatment of the various topics. Generally speaking, this book is very well integrated and provides a complete resource that adequately covers all critical aspects of digital radiology and PACS. I highly recommend *PACS: A Guide to the Digital Revolution* for professionals who are interested in the growing field of PACS and the digital revolution in the field of radiology.