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Feature Articles

Diagnostic Imaging in the 1980s: Quo Vadis?

In the last decade, four major trends have emerged that are fundamentally reshaping the nature and role of diagnostic radiology. The most obvious trend is the exponential rate of development of new imaging technology. Many technical advances center around the computer and conversion from analog to digital imaging. For several imaging modalities, the culmination of this trend has been the development of systems wherein the image is acquired, stored, displayed, and analyzed entirely in the digital rather than the analog format of traditional radiography. For some modalities, including nuclear medicine, ultrasonography, plain film radiography, and angiography, the digital approach offers the potential of completely replacing conventional analog techniques. Digital images appear quite similar to analog images. From a practical standpoint, it is not possible to record analog images of computed tomography or magnetic resonance since images of these modalities are constructed from thousands of individual quantitative recordings. In computed tomography, the measured parameter is the attenuation of an X-ray beam; in magnetic resonance, the measured parameter is the strength of the radiofrequency signal from hydrogen nuclei in the magnetic field. Thus, the spectrum of digital imaging begins with simple digitization of conventional analog images and continues through entirely new types of computed or parametric images.

In addition to the new digital imaging systems, the availability of sophisticated computer technology has resulted in the development of computer networking systems to transfer image data electronically from one location to another. The development of picture archiving and computing systems (PACS) is directed toward total integrated computerization for image storage, retrieval, and analysis. These systems will be the heart of the filmless radiology department envisioned for the future and the basis of the multimodality review stations that will permit the radiologist or clinician to retrieve and compare ultrasound, computed tomographic, or magnetic resonance images side by side on a display console.

Another direction of the digital imaging-computer processing trend is the increasing potential for quantitative analysis of image data. Simple measurement of anatomic structures, eg, pelvimetry, cardiothoracic ratio measurements, has long been a cornerstone of conventional radiology practice. With computer processing, it is now possible to extract information on the relative intensity of structures and to analyze quantitatively dynamic studies to calculate flow and perfusion parameters. For example, highly accurate measurements of bone density are being made by dual-energy CT scanning of the spine. Likewise, coronary perfusion may be assessed quantitatively by digital subtraction angiography.

While the development of new complex technology garners many of the headlines, other developments have also had direct clinical impact. Radiology is turning increasingly to diagnostic algorithms to determine the proper selection and sequence of studies. With the plethora of new imaging modalities — hence, the multiple possibilities for examining each organ system — it has become necessary to develop algorithms for their orderly application in a diagnostic work-up. Algorithms are designed to provide the fastest and most cost-effective answer to a given clinical question. A typical example of this would be the choice of procedure used to examine a patient who has right upper quadrant pain, possibly due to acute cholecystitis. In many centers, a radionuclide hepatobiliary scan would be performed to evaluate the patient's condition. Visualization of the gallbladder effectively rules out this condition. If the gallbladder is not visualized by radionuclide scanning, an ultrasound examination might be indicated to look for stones in the gallbladder and the cystic and common bile ducts. On the other hand, a different sequence of imaging procedures would be followed for examination of a jaundiced patient: ultrasound would be the examination of choice to assess the size of the bile ducts and thereby distinguish obstructive from nonobstructive etiologies (surgical vs medical jaundice).

The major limitation of the algorithmic approach is the need to have a well-defined clinical starting point. This starting point is determined by assessing all available information, including the results of any prior tests. Good algorithms are somewhat elastic and are aimed at differential diagnosis as well as toward establishing specific diagnoses. They must take into account not only the most likely diagnoses but also conditions that are potentially the most detrimental to the patient, even if these are less likely.

A third major trend in diagnostic imaging is the development of hybrid diagnostic-treatment procedures. These techniques have actually been performed for many years, but with the advent of procedures such as transluminal angioplasty and percutaneous renal stone extraction, the concept of using a diagnostic imaging modality as a guide in performance of a therapeutic maneuver has become better recognized and more broadly practiced. The term "interventional radiology" is often applied to these hybrid procedures that have as a common thread the concept of using an imaging technique to guide a therapeutic procedure.

The discipline of radiology has continued to expand its role in the study of physiology and biochemistry as well as anatomy. A number of interesting pharmacological agents are being used adjunctively in positron emission tomography and

magnetic resonance imaging to obtain information on actual biochemical organ function. While anatomic assessment remains the foundation of radiologic diagnosis, much of the growth — and certainly a great deal of the intellectual interest and excitement in the field — will come from these studies in biochemistry and physiology.

In summary, medical imaging is an extraordinarily dynamic and robust field. Its horizons are being expanded with new technical developments that, in turn, have underwritten the ability to study physiologic and biochemical parameters. The field is no longer purely diagnostic but increasingly therapeutically oriented. The intelligent application of imaging

technology will necessarily require a systematic (algorithmic) approach to limit what would otherwise be an exponentially upward spiral in health-care costs.

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