Clinical Informatics As A Medical Subspecialty

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AT THE LAST TURN OF THE CENTURY, a number of new diagnostic modalities were coming into widespread use. With these modalities came a cadre of physicians who concentrated their time, and eventually limited their practices, to developing expertise in the application of the new modalities to patient care. Among these new modalities, radiology emerged from the efforts of those experimenting with Roentgen's new X ray. Pathology and laboratory medicine grew from the efforts of those who studied disease in the research laboratory, using morphologic techniques and microscopy.

Again at the threshold of a new century, we are beginning to take hold of a new array of diagnostic (and therapeutic) technology — clinical informatics. Informatics is far more than just the use of computers. Indeed, some of the most important problems and issues in informatics today have absolutely nothing to do with computers. However, computer technology has given us a power tool to accomplish information management tasks that were totally unachievable just a decade or two ago. Just as radiology is continuing to pioneer new technologies and modalities to see within, clinical informatics is well positioned to continue applying newly developed information management tools to diagnosis and management of the patient.

The American Board of Pathology has recently proposed a definition of the discipline "clinical laboratory informatics." With minor change it becomes a functional definition of the entire clinical informatics specialty. I have also added the word "safeguarding," as proposed by Thomas Lincoln, MD, to emphasize the central importance of confidentiality and data integrity:

> Clinical . . . informatics. . . focuses on the management (generation, collection, organization, validation, processing, storage, integration, interpretation, communication, and presentation [and safeguarding]) of information and systems in support of patient care decision making, education, and research.

THE INFORMATICIST'S ROLE

Informaticists design, select, and build infrastructure to enhance patient care and ensure that optimum systems are selected for each medical activity. [1]

Automated information processing greatly improves patient care services, but as physicians, we must make use of the tools provided by information systems and build additional ones to benefit patients. Because information processing has been at the very core of medical practice for more than a century, control over the functioning of our newly

automated information systems will become tantamount to control over the medical decisions.

Informaticists also pioneer the direct application of automated information systems for individual patient care decisions. Just as the general internist has learned how to read a chest X ray, and the hematologist a bone marrow biopsy, the primary care physician must become thoroughly comfortable with new generations of information processing tools. However, the informaticist must lead the way, to provide a model of how these tools can be applied to patient care.

The clinical informaticist must also apply systems for policy decisions affecting many patients, and assist his or her colleagues in medicine to learn about systems. Finally, this practical experience in using and teaching about such systems will facilitate the work of the informaticist in revising and improving system function, and evolving toward the next generation of systems.

INDIVIDUAL PATIENT CARE DECISIONS

One role that distinguishes the practitioner of medicine from a technician, scientist, or manager is responsibility for decisions affecting the care of individual patients. It is important for clinical informaticists to maintain such a role, not only because we are most qualified to bring the tools of modern information technology to bear on individual patients' cases, but also so that we can teach our medical colleagues how to use these tools. [2] Our ability to care for patients is greatly facilitated by having all relevant patient-specific information readily available, through use of the emerging electronic medical record.

In selecting, interpreting, and determining the significance of diagnostic studies, physicians have traditionally relied upon memory, textbooks, libraries, and (in selected cases) consultants. The informaticist uses these traditional tools, plus automated search of recent literature (via Medline), full-text electronic knowledge sources, knowledge-based systems (both standard and supplemented with local cases), comparison of the patient with others in local or national data bases, and consultation via electronic mail with colleagues around the country (and the world).

The clinical informaticist can also take a proactive approach. Rather than waiting to be told about the cases in which he or she might be called in as a consultant, the clinical pathologist informaticist (for example) can request electronic notification of certain admitting diagnoses, unusual test orders, or exceptional results. The quality and value of the informaticist's evaluation will be enhanced as more complete and reliable patient information becomes available electronically.

Diagnostic challenges in morphologic specialties, including images as diverse as electronically generated scattergrams, endoscopic photographs, and microscopic histologic and cytologic patterns, will be more effectively managed by supplementing traditional information sources (memory, textbooks, atlases, journals, and consultants) with the informaticist's novel tools: more complete clinical data (via the electronic medical record), electronic atlases and image data bases, knowledge-based image archiving systems, electronic image analysis, and telemedicine to facilitate consultation.

Those of us in specialties with severe labor shortages, such as clinical pathology, are seeking tools to leverage our time and expertise so that we may provide care for more patients than our time currently permits. Information systems provide powerful capabilities, with proper professional supervision, to automatically provide interpretive assistance to clinicians (for example, on hepatitis serology panels, thyroid testing, or cardiac risk factors). [3]

We can also provide guidance to clinicians in test ordering, and in selection and monitoring of therapy. An automated, "smart" formulary can assist in drug selection, dose calculations, interaction detection, and many other critical decisions.

In another example, indications for therapy can be validated and documented — for example, the recent development of a transfusion order workstation by Don Connelly, MD, at the University of Minnesota. [4] Medical staff policies can be enforced prospectively, including review of expensive antibiotics when there are inexpensive alternatives with equal susceptibility of clinical isolates, and clinical criteria for use of cytokines.

Electronic order entry systems facilitate the review of previous results and other significant data, and provide automatic reminders and linkage to electronic mail. They also make possible a crucial step — that of closing the loop to ensure significant findings are acted upon. Systems can automatically correlate pathognomonic findings with expected therapy, appropriate follow-up testing, and appearance of the condition on the patient's diagnosis or problem list. If one of these has not occurred within a few days of the reporting of the pathognomonic finding, a more explicit reminder can be provided to the clinician.

SUPPORTING CLINICAL AND SERVICE QUALITY

As physicians, we are often called upon to work toward improving quality and appropriateness of patient care services. In a diagnostic ancillary, the validity of diagnostic tests is a key issue in these efforts. For example, the clinician may tell the clinical pathologist that "all your potassiums are too high." Traditionally, we would have reviewed the quality control value, and concluded that the clinician was mistaken. With informatics tools, we can now use the patient result data base in our laboratory information system, examine daily mean values and histograms, and stratify the data base by physician, patient age, and other parameters. Stratification by physician confirms the (isolated) problem, and a quick call to the office reveals the source — refrigeration of serum specimens before separation from the clot. We have also used such techniques for review and update of reference ranges.

Another common question faced by diagnostic and therapeutic departments is our level of service: succinctly put, we are told "your service is too slow." Rather than the display of a single parameter to "prove" to the clinician that he or she is mistaken, the clinical informaticist researches the data base, looking at turnaround time at various times of the day, locations, or patient types, as well as evaluating results availability versus clinical need (e.g., do the results become available 30 minutes after the patient has been discharged?). Even issues of report clarity and routing can account for perceived unavailability of results.

Informatics provides us with mechanisms to prevent patient care problems before they occur by identifying patterns of logistic or system failures, modifying standard systems to avoid such failures, and building automated rules to predict and prevent failures.

THE INFORMATION INFRASTRUCTURE

Front-line patient care has depended on the paper chart, the pen, the clinician's memory, the telephone, and the medical library. Over the next decade, these century-old tools will be replaced by the on-line, electronic patient care record.

Some institutions have made a beginning. For example, Long Beach Memorial Medical Center has a wide variety and depth of patient data available electronically on several hundred workstations throughout the medical

Figure 1.
Data Available Electronically at Long Beach Memorial Medical Center

Admitting/face sheet information
All orders
Patient data, diagnoses, procedures, etc.
Results: lab, radiology, EKG, ultrasound, etc.
Admitting histories and physicals, discharge summaries, operative reports, etc.
Medication administration records
Nurses' notes

center, as well as in physicians' offices and homes (figure 1).

Towards the electronic patient record

Clinicians use the patient care record on a daily basis and are aware of the scope of information needs for patient care. Nevertheless, care must be taken to involve clinicians with a broad perspective — avoiding "micromania and the instant expert syndrome." [5] Also, we must remember that the realm of clinicians includes primary care physicians, specialists, nurses, physical therapists, pharmacists, and other professionals.

How should clinicians be involved in the process of developing the on-line record? Are monthly steering committee meetings sufficient? Should they be brought in on specific projects as consultants? Should their input be solicited by one-on-one, ad hoc interaction with the information systems department, as "techie" doctors asked detailed questions? Or is presence at the quarterly meetings of the medical staff sufficient?

These traditional approaches have been used (with little success) by hundreds of hospitals. We believe that adequate involvement of clinicians will occur only when they become salaried members of the information systems team. [6] Good arguments can be made that they will be most effective on a part-time basis — the rest of the time can be devoted to practicing medicine on individual patients, having to *use* the tools that have been implemented by the information systems team. [7,8]

Thus, clinical informatics constitutes a new subspecialty of the practice of medicine. It possesses a distinct body of knowledge, evidenced by textbooks, journals, and meetings focused on the subject. Medical practitioners of clinical informatics include physicians with a wide variety of primary specialties — from pathologists (who have long been involved with both laboratory and hospital-wide informatics issues), radiologists, and anesthesiologists, to internists, surgeons, dermatologists, and virtually every other specialty. Just as group practices have traditionally sought to recruit associates with specialized skills (e.g., expertise in laparoscopic surgery, hematopathology, invasive cardiology, or transfusion medicine), groups will now seek expertise in informatics. The specialist in clinical informatics will improve the efficiency of his or her colleagues, while assisting them in diagnosis and management of patients. Quality improvement is another area of particular expertise and focus.

The emergence of this new medical subspecialty does not in any way diminish the essential contributions that continue to be made by our nonphysician colleagues specializing in medical informatics. Medical informatics is a broader concept encompassing a wide variety of educational backgrounds, including nurses, librarians, pharmacists, educators, and many others. [9,10] There are several national organizations dedicated to medical and clinical informatics, and several medical schools and hospitals have departments, or

Figure 2.
Topics Covered in Informatics Training.

- Generation of information
- Collection: conversion of all data for clinical decision making into electronic form
- Organization: patient ID, coding systems, organ system metaphor
- Validation
- Processing: inherent constraints and capabilities of information technology
- Storage: patient data and medical knowledge
- Integration: diverse information needs for different areas, practitioners
- Interpretation
- Communication: media, standards, non-hardcopy reports, electronic mail
- Presentation: report production, user interface
- Safeguarding: integrity, access control, confidentiality
- Organizational leadership, information flow, and management in various sections, divisions, and departments
- Quality improvement
- Justification of automated information systems
- Systems selection, contracting, implementation, and maintenance
- Organizational aspects of informatics
- Regulatory issues and requirements
- Education
- Research
- Physician workstation — "tabletop computing"
- Computer technology (present and future)
- Resources: books, journals, meetings, and vendors
- Career opportunities in clinical and medical informatics

divisions, of medical informatics.

It is likely to be several years before clinical informatics is an approved certification of the American Board of Medical Specialties (ABMS). Although the American Board of Pathology (ABP) in November 1991 sent ABMS a letter of intent to develop a proposal, it normally takes five to ten years for all the necessary documentation to be assembled and approved. In the meantime, the ABP has appointed a test committee on informatics and laboratory management, which will develop questions for the general certification examinations in pathology.

A variety of training opportunities exist for those medical practitioners interested in developing expertise in clinical informatics. Residency programs in several specialties (particularly pathology and internal medicine), include options to focus on informatics. [11] Several universities offer research-oriented fellowship programs, often leading to an advanced academic degree (master's or PhD); a number of these have been funded by the National Library of Medicine. Recently, increasing numbers of fellowships in applied informatics are being created. Finally, many of the specialty societies provide continuing education opportunities — mostly didactic, but a few apprenticeship. Figure 2 shows the topics that may be encompassed in an informatics training program.

INFORMATION AND FEEDBACK

A complete listing of books, journals, technical magazines, national meetings, electronic resources, and other sources of information on clinical informatics is beyond the scope (and space constraints) of this article. However, the author will be happy to supply a list in response to an electronic mail inquiry or a letter with self-addressed envelope.

Also, I welcome any comments you have on this topic, and encourage you to write to me by conventional or electronic mail. I'm particularly interested in hearing from readers who practice

clinical informatics, with specific accounts of how your practice has benefitted the care of patients.

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