The Next-Generation Emergency Department

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The greatest advances in medicine over the next two decades will result from application of the tools and principles of informatics to the problems of clinical medicine. New developments in medical informatics will drive advances in clinical care, administration, research, and education. Information flow in the emergency department a decade hence will be characterized by a transformation from a "hunter-gatherer" information model to a "publisher-subscriber" model in which the right information will always be available at the right time. In large part, information will be gathered automatically rather than manually. Computers will be ubiquitous and almost invisible. Invasive and attached monitoring and testing will yield to new remote and noninvasive technologies. Information will be shared and modified as needed, rather than recreated and reentered by each caregiver. Eventually, the use of information technologies in the emergency medicine workplace will enhance our traditional role as hands-on providers of direct patient care.

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INTRODUCTION

Years of effort to peer beyond the event horizon have convinced us that the next 10 years will be an exhilarating time to be practicing emergency medicine. During the next decade, emergency physicians will be privileged to be present at nothing less than a total transformation of today's practice environment. This revolutionary transformation will be brought about by changes in the economics and organization of medicine and will be fueled and enabled by the new tools of information technology.

In the next 10 years we will see significant refinements in our information tools. These information technologies will continue to become faster in response, smaller in size, larger in capacity, and substantially smarter. Despite the magnitude of these future advances, most of the technology that will transform the practice of emergency medicine already exists today. It is not a matter of waiting for new technologic breakthroughs but merely of applying the technologic riches that we already have.

Our vision of the emergency department of 2008 is sketched out in a series of short observations that place an emphasis on advances in information flow. Our vision of the ED workplace 10 years from now owes much to our experience of building (with varying degrees of success) information management systems in two different EDs. We suspect that these insights gained at the "bleeding edge" will be as timely and true in 2008 as they are now.

MOVING FROM THE PAST TO THE FUTURE

The professionalization of our specialty, the establishment of residency training programs, and the respect with which we are held by our peers have all contributed to a great revolution in our specialty in the past 15 years, but this change has been almost entirely extraclinical. The actual practice of emergency medicine in most EDs today—how we evaluate a specific patient complaint, how we manage a given clinical condition, how patient flow is handled, how the processes of care are organized—is only incrementally different from what it was 15 years ago.

For example, many EDs use the same patient locator swipe boards that have organized information and tracked patients for decades. Throughout this time, we have written on the locator board the same key information: the patient's last name, location in the department, time placed into room, nature of complaint, doctor-nurse team assignment, and a smattering of special information. Some departments use the board to record orders given and orders taken off. To upgrade a 1980s patient locator board into one for 1998, one need only add columns for the patient's managed care organization and "gatekeeper."

Almost the same thing is true of the paper chart. Although some EDs use dictation, computerized voice input, or a "point and click" computerized medical record, most still use a traditional free-form paper chart. Today's paper chart may be longer, more complicated, and more oriented toward reimbursement and medicolegal perspectives than it was 15 years ago, but it is only incrementally different.

Where true advances have been made is in the domain of diagnostic and monitoring equipment. Many ED patient bays are equipped with physiologic monitoring stations for cardiac rhythm, pulse, and blood pressure, as well as for pulse oximetry, which did not exist in the ED of the early 1980s. Computed tomographic scans are now such a common part of the ED workup that the scanner may even be located physically within the ED. Bedside ultrasonography, point-of-care laboratory testing, computerized laboratory results reporting, and on-line availability of previous ECGs are other evolutionary differences that distinguish the ED of 1998 from that of 1980.

Changes also have occurred in the ways that certain clinical conditions are managed. Emergency physicians perform procedures that previously were done by other specialists (eg, rapid- sequence intubations), use new types of medications (eg, thrombolytic therapy for myocardial infarction), and rely on new diagnostic tests (eg, creatine kinase-MB, troponin I, and troponin T). Yet the impacts of all of these changes, taken singly or together, will be dwarfed by the revolutionary transformation that is to come.

The pressures from our customers—patients, insurance companies, managed care organizations, stockholders in for-profit medical enterprises, and federal and state governments—are forcing a reformation in the practice of medicine. Competition is king, and economic survival in a competitive marketplace depends on accurate information about the product or service being produced. Emergency physicians today are being held accountable for the costs of diagnostic and therapeutic management choices, for the quality of results, and for the satisfaction of customers. We suddenly must be able to track and quantify the costs, processes, and outcomes of clinical medical care and to demonstrate that care is being delivered in a timely, fast, efficient, and consistent manner.[1]

In response to competitive pressures, the practice of medicine in the next 10 years will be characterized by change along five axes:

- Resource utilization (we will do things more cheaply)
- Productivity (we will do things more efficiently)
- Quality (we will do things better and have better outcomes)
- Service excellence (we will do things more graciously)
- Measurement (we will quantify what we do)

Improvement in these areas will require that information be organized, presented, and managed in more powerful and comprehensive ways. In a practical sense, our ability to apply information technology will define and shape the program of change in our specialty. The demands of the external practice environment will force us to become ever more reliant on information technologies, even if we are not persuaded by the intrinsic benefits and inherent rationality of this change.

In 1998, any private citizen with a computer can pinpoint the exact current location of an overnight delivery package that is en route to a destination 3,000 miles away, but in the typical ED of 1998 it is often impossible to locate a chart that can be no more than 30 feet away. The power of currently available information technology is spectacular, yet surprisingly little of that power has been applied to medicine.[2,3] Unlike information in other industries, medical information is still managed much as it was in 1975. A few EDs are fortunate enough to benefit from computerized medical records, computerized tracking of patients, and immediate access to all current and old diagnostic information about a patient, but the majority continue to practice in a traditional "pen-and-paper" mode.

Much of a physician's time in a busy ED is spent looking for charts, tracking down laboratory results, trying to find a patient or a staff member, and repeatedly recording information that someone else has already recorded. Often, more time is spent in searching out and recording information than in synthesizing and analyzing the information after it has been recorded or found. It is surprising that the ED works as well as it does, considering the number of steps and people involved in even such a seemingly simple process as obtaining a complete blood count, a procedure that may require the involvement of six or seven people and a complex and variable chain of communications. A similarly complicated process is required for virtually every piece of information sought, whether it be an arterial blood gas analysis, old medical records, or a chest radiograph. Each step in the process introduces its own potential for delays and mixups, and the chain is only as strong as its weakest link. It is instructive and sobering to perform an information flow analysis for each of the procedures and data items that are used in one's own ED.[4] The "paperware" that undergirds our present-day system of care is inefficient, inaccurate, and incomplete and forces redundant effort. The handwritten chart can be viewed by only one person at a time, and by its very nature it is often illegible, slow and labor-intensive to retrieve, and missing or unavailable when needed.

This present sorry state of affairs cannot persist. Emergency medicine is at such a rudimentary stage of information management that vast gains may be made with relatively simple improvements. Even if all we do is implement what the banking or airline industries have done, without even applying any of the cutting-edge technology that has been developed in the past few years, we will dramatically improve the efficiency of our work environment. As the incorporation of information technology into emergency medicine practice gains momentum, 30 years of overdue change in information management will be compressed into the next decade. This is a strategically advantageous time for those of us who are working to advance the practice of emergency medicine, because at this very early stage of change there is great opportunity to make a major impact at a very reasonable cost in time and effort.

Simple, inexpensive, and easily implemented technologic solutions can often fix problems which would otherwise require time-consuming programs of personnel management and restructuring of behaviors.[5] An elegant technologic solution often produces a collective "Aha!" as all concerned recognize the achievement of a true efficiency, producing more benefits at a lower cost in resources. Two examples illustrate the power of simple technology to solve problems that are refractory to behavior modification.

In a busy ED, telephone callers who were placed on hold in a silent digital telephone system were bored and annoyed by the time their desired party finally picked up the telephone. An extensive staff training effort to reduce "time on hold" failed miserably, but the simple addition of classical music on hold was immediately successful in converting formerly tense and hostile callers into relaxed and happy ones.

As a second example, the triage nurse in the same ED often was embarrassed when a patient was brought to a supposedly empty examination room that had recently been usurped for another patient. Efforts to solve this problem through training to produce behavior modification were unsuccessful, but the installation of a television camera aimed at the patient locator board and a monitor placed in the triage booth was immediately successful because the triage nurse could see at a glance which rooms were empty at the very moment when that information was needed.

Simple technologic solutions such as these can seem like quantum jumps because they can obviate the enormous costs of implementing incremental changes in ingrained processes—the extraprocess cost of retraining personnel, the cost of monitoring the new behavior, and the additional operational cost of actually performing the altered process.

The introduction of new technologies to assist in old processes can be of value, but the reorganization of emergency medicine practice to take advantage of information technologies is much more than simply the electronic automation of tasks that are now performed manually. The manual processes and procedures used in today's ED evolved with yesterday's constraints in response to yesterday's needs. The goal of improved information management is not to "throw computers" at yesterday's broken processes, but rather to redesign our processes using the principles and techniques of information management as the tools to enable that reengineering. Simply automating yesterday's processes has been referred to by Michael Hammer as "paving the cowpaths." He recommended, "Instead of embedding outdated processes in silicon and software, we should obliterate them and start over."[6] Ten years hence, we will not have a computerized version of today's ED, because the natural processes and practice of emergency medicine will be dramatically different after the information infrastructure has been reengineered.

Information in the ED of 2008 will be characterized by legibility, simultaneous availability in multiple locations, and the ability to be audited and authenticated. It will be captured through processes that can enforce completeness and relevance. The information will be readily retrievable, filterable, sortable, and searchable. It will be managed with the use of systems that can produce alarms and alerts based on any arbitrary conditions, that are designed to prompt and remind, and that can serve as decision aids for health care professionals. It will be immediately and easily available for research, management monitoring, quality control, and ongoing process improvement. Most importantly, it will be easily and securely shared with other health care workers and easily delivered to other information management and analysis systems no matter where they are located.

These advances will change how we practice emergency medicine and will do much more than any specific new diagnostic or therapeutic breakthrough to improve the care we can give our patients. This is true because physicians are fundamentally information workers, whose main task has always been to obtain, filter, analyze, and synthesize information about a patient's clinical problem and then to make decisions and take actions based on that synthesis. In the ED of 2008, the creation, acquisition, retrieval, filtering, and organization of information will be done better, done faster, and done automatically, leaving more time for the real practice of medicine. The information system will present the right information to the right clinician at the right time, formatted in the right way to meet the information needs of the moment. Physicians will spend more time analyzing information, making a diagnosis, selecting therapy, doing procedures, assessing outcomes, addressing patients' concerns, and simply taking care of patients.

With improved information flow and control, we will achieve an unparalleled combination of the ability to move patients and the ability to move information. When this happens, the locus and scope of emergency medicine practice will change as well. Remote evaluation, treatment, and advice (using telephones and other forms of telemedicine) will allow expanded access to emergency care while simultaneously permitting a more focused use of acute medical transportation systems. Patients will be brought to the physical ED only when necessary. Emergency physicians will no longer be individual patient practitioners, treating only those patients who present themselves to EDs, but global managers of the medical emergency and urgency needs of entire populations of patients.

ADVANCES IN TECHNOLOGY

The information engine of the ED of 1998 is characterized by intrusive computing, invasive monitoring, manual information acquisition, single representation of information, multiple people involved in the chain of information generation, redundant entry of information, individualized care processes, and serial processing of patients. In contrast, information flow in the ED of 2008 will be characterized by ubiquitous rather than intrusive computing, monitoring that is remote and noninvasive rather than attached and invasive, information gathering that is automated rather than manual, ubiquitous availability of demographic information, multiple rather than single representations of information, fewer people involved in the chain of information generation, modification rather than redundant recreation of information, uniform rather than "individualized" care processes, and parallel rather than serial processing of patients.

Ubiquitous computing

Alan Cooper, one of the fathers of modern graphical computer programming, is famous for his admonition to programmers: "No matter how good your user interface is, less of it would be better."[6a] The ultimate future user interface will be no perceivable interface at all: computers will be omnipresent but largely invisible. This situation has been called "ubiquitous computing" by Mark Weiser, formerly of the Xerox Palo Alto Research Center, who writes, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."[7] Weiser points to the example of written communication, a technology that is ubiquitous in industrialized countries: "Not only do books, magazines and newspapers convey written information, but so do street signs, billboards, shop signs and even graffiti. Candy wrappers are covered in writing. The constant background presence of these products of 'literacy technology' does not require active attention, but the information to be conveyed is ready for use at a glance. It is difficult to imagine modern life otherwise." In contrast, the state of the art in computing today is "perhaps analogous to the period when scribes had to know as much about making ink or baking clay as they did about writing."[7]

When computing is ubiquitous, we will have combined the power of computer technology with the ease of manipulation usually associated with pen and paper, thus achieving what Frisse has referred to as "transparency."[8] The machines themselves will be in the background rather than in the foreground, and the user will perceive only the results. Computers in the ED will be easy to use and transparent, working their magic behind the scenes, like the computers that manage the fuel delivery in our cars or the "intelligence" behind a machine-generated interpretation of an electrocardiogram.

As a trivial example, consider the recording of the time at which a physician sees a patient. With a paper chart, that time must be handwritten onto the chart. With an electronic chart, the time at which the note is written is recorded automatically, and the time at which the physician saw the patient is either explicitly entered or inferred from the time of the note. In the ED of the immediate future, ubiquitous computing will provide effortless tracking of personnel. An off-the-shelf application that is commercially available today can detect when a physician is in the presence of a patient by means of infrared-emitting badges attached to each patient and each staff member. An even more advanced biometric recognition system already exists that can analyze real-time video images to recognize individuals and track the locations of staff and patients based on appearance alone.

Remote and noninvasive monitoring

If the temperature and sodium content of interstellar gas millions of light years away can be assayed by spectrophotometric methods, a patient's temperature and serum sodium should be able to be assessed noninvasively from a few inches or a few feet away. This is not "science fiction" but the natural result of current trends in research and development. A decade ago, invasive arterial blood gas measurements were the only way to assess oxygen saturation. Pulse oximetry was a rare and expensive proposition available only in the research setting. Today, noninvasive measurement of a patient's oxygen saturation is taken for granted, noninvasive home measurement of serum glucose is undergoing clinical trials, and photometric measurement of other serum components is being performed in the research laboratory.

A brief look at new technologies that are already available in the research setting suggests that in the future the measurement of many other physiologic attributes as well as blood and serum components will be equally noninvasive. Commercially available, off-the-shelf systems using external bioimpedance sensors today permit noninvasive determination even of such ordinarily invasive measures as cardiac output, stroke volume, end-diastolic volume (preload), index of contractility, acceleration index, systemic vascular resistance (afterload), left cardiac work, systolic time ratio, thoracic fluid content, heart rate, preejection period, left ventricular ejection time, and mean arterial pressure.

Standard 12-lead electrocardiography today is performed by attaching 10 wires to specific locations on a patient's body. Existing methods for sensing and analyzing electromagnetic field perturbations can acquire much more detailed information with the use of fewer sensors, and laboratory techniques can acquire such information through remote sensors that are not attached to the patient at all, permitting an ECG (or even an EEG) to be obtained from across the room.

Automated capture of physiologic information

A few years ago, a prediction that automated measurement of pulse and blood pressure would largely replace manual sphygmomanometry seemed preposterous, given the simplicity and dependability of the traditional manual systems. Today there are many EDs in which a manually obtained blood pressure reading is rare indeed, and automatic addition of these automatically obtained readings to the clinical chart has become a reality. This trend toward automatic capture and charting of physiologic data will continue as today's exotic technologies move from the laboratory to the clinical research setting and finally into the mainstream of clinical practice.

There are a very large number of interesting technologies that already exist in specialized settings or are in use in fields outside of medicine. There are cardiac rhythm recorders and event monitors built into a wristwatch. There are stretchers and floor tiles that have strain-gauge scales built into them to measure body weight. There are ultrasound monitors that can record respiratory rate[9] and ambient air samplers that can assess many components of exhaled breath, using approaches similar to those used when exhaled carbon dioxide detectors monitor the respirations of intubated patients.[10,11] There are thermographic sensors (similar to the passive infrared detectors used in today's inexpensive home burglar alarms) that can detect the exhalation of warm air and report the respiratory rate at the same time that they measure periodic fluctuations in surface-radiated heat and calculate a patient's heart rate and body temperature. An existing radar flashlight, developed for remote monitoring of athletes at the 1996 Olympic Games, can measure heart rate and respiratory rate not only through the patient's clothes but actually through the wall of a building. Pupillary size, shape, and reactivity to light can be automatically assessed and recorded by the same scanning laser that is used in a modern video camera to track eye movement and set focus. Even measurement of a leg or arm circumference with a tape measure could become a thing of the past, because body contour information can be more reliably obtained using the same scanning technologies that are employed today to create digitized characters for children's video games.[12] As in the past, innovative technologies will continue to move from the laboratory, to the clinical research setting, and finally into the mainstream. Just as the manual taking of blood pressure has been replaced by the "automatic" blood pressure cuff, automatic acquisition will become the standard means of obtaining almost any physiologic measure.

Reuse and modification of existing data

Demographic information, now entered manually at significant cost, already exists in a number of external systems that can be tapped to provide the information to the ED registration record in a seamless way. An accessible demographic record exists whenever a patient has received any talisman of modern life—a driver's license, an identification card, a credit card, a bank checking or savings account, a traffic ticket, a felony conviction, a telephone number—or has visited a hospital or engaged in any of a host of other common activities. The process by which today's registration clerks laboriously ask each patient the same questions on each visit to the ED will become a thing of the past.

In addition to demographic information, the amount of redundant recording of clinical information that is done today is quite large.[2] In an information-enabled environment, all personnel involved in caring for a patient will be working from the same distributed computerized medical record. Within the ED, the triage nurse (if such a position even exists in the ED of 2008), the primary nurse, and the emergency physician will all contribute to the same patient history database. In large measure, data will be recorded only once, and information recorded by one caregiver will be available automatically to all. For example, information on allergies and medications recorded in an outpatient office last week will be automatically displayed for verification and modification in the ED today. No longer will the names of the medicines being prescribed to a patient be written on the chart and then written out again on the prescription itself. Renewal of an existing prescription will be performed with a simple voice command or a single mouse click. A change in the dose of an outpatient medication will take the form of a "dosage change order" rather than an entirely new prescription, something that today is possible only within an inpatient setting.

Multiple representations of information

Airline reservations and concert ticket sales are good examples of information that is shared rather than singly represented. The sale of an airplane seat or a concert ticket from an office in Duluth is instantly known to travel agents or ticket sales offices all over the world. The paper-based ED patient chart, in contrast, exists only in a single representation, and the three words most commonly uttered in the typical ED of 1998 may well be "Where's the chart?" The time that is wasted looking for singular representations of information in the ED will be recaptured when each patient's clinical information can be accessed simultaneously by any number of caregivers and represented in many different ways in multiple locations, with no time lag in the ubiquitous availability of new information once it has been gathered or generated.

Fewer people involved in information generation

Today most EDs handle information flow via a "Rube Goldberg" approach that will test the credulity of our future colleagues. The convoluted process by which laboratory tests are ordered and results obtained cannot long endure in this era of new information technology. In the ED of 2008, for those tests that are not yet automatically and noninvasively available for all patients, we will have bedside ("point-of-care") laboratory testing in the ED. A single technician will handle the entire transaction, compared with the six or seven people who may be involved in such a process today.

Uniform care processes

Traditionally, patient care has been delivered in a highly individualized manner. Where standard approaches have been used, they have come into being through an ad hoc process in which unproven algorithms are popularized through generations of textbooks. The availability of reliable and current information about our practice and about the outcomes of our populations of patients will facilitate the adoption of self-tuning or self-improving algorithms for the management of many common problems.[13] Emergency medicine is well suited to algorithmic clinical practice guidelines because the physician-patient interaction is time-limited and is often focused on a single problem. When real-time monitoring of all diagnostic and therapeutic interactions is available, it will be easy to design, implement, enforce, track, analyze, and improve clinical management algorithms without unduly disturbing clinical practice. Algorithmic clinical pathways will eventually facilitate some part of most patient encounters, and the overall quality and consistency of care will be improved.

Parallel processing of patients

The traditional ED has a "conveyor belt" feel to it. Patients are processed serially through triage, registration, nursing evaluation, resident physician evaluation, attending physician evaluation, radiology, laboratory workup, consultation, and so forth. The system functions best when there is a steady stream of patients, with all components of the system working at maximal capacity and no one in queue waiting for service. What happens when the stream is not steady or the numbers not optimal is that some personnel in some areas are not productive ("sitting around doing nothing") while at other sites (eg, registration, triage, radiology) there is a long line of patients waiting. The system is not agile and cannot easily adjust its capacity to meet changing need. In reality, the tasks that must be completed (eg, registration, initial nursing assessment, physician evaluation) need not be done in a rigid order nor in only one specific physical place. The introduction of technology to provide ubiquitous access to shared information will encourage multiple points of entry for a patient into the care system and multiple pathways through the process.

Advances in technology will make it easier for medical personnel to fill a variety of different roles within the functioning department, depending on the need of the moment (staff "polyvalency"). For example, in the not too distant past, such tasks as obtaining an arterial blood gas sample and administering certain intravenous medications were the exclusive purview of the attending physician and had to await the availability of that physician. Increased training and increased autonomy for nurses has allowed these functions to proceed even when the attending physician is otherwise engaged. Pulse oximetry, premixed medications, and automatic pumps have brought even more flexibility and agility to the system.

In the same way, modern information technology will free us from the physical locus constraint of where processes are done and who performs them. The process of registration can (and in some centers already does) occur at the bedside. The process of physician care can occur in the "triage area." The process of laboratory testing can occur in the "radiology area." When registration involves only the biometric identification of a patient (perhaps by scanning the patient's face, iris, fingerprint, or hand morphology) followed by confirmation of the demographic information obtained by computer from some other source outside or inside the hospital, anyone can register a patient in any location.

Registration is not the only function that lends itself to polyvalency. When test ordering does not require "secret knowledge" about the process, anyone can perform the task in any location. When vital signs, pulse oximetry, and laboratory testing are noninvasive and the results are logged automatically, they can be done anywhere—and by people who previously were not deemed adequately trained to do so.

Even such seemingly knowledge-intensive tasks as obtaining radiographs can be automated sufficiently to support polyvalency. The latest systems for teleradiology already incorporate standard preprogrammed intensity, current, and time settings for common imaging tasks. Programmable ("robotic") positioning tables can provide automatic positioning for any commonly ordered radiograph. Existing direct-to-digital imaging systems can provide real-time feedback to the x-ray source during the exposure (just as an automatic camera controls the duration of its flash) so that films are never under- or over-exposed. Finally, unlike a wet film, the digital image needs no development and is immediately viewable by the radiologist and the emergency physician simultaneously.

THE VIRTUAL PATIENT RECORD

With the implementation of effective information technologies in the ED and throughout the hospital, the paper patient record will initially be replaced by a computerized patient record stored in a single database. This change, although necessary, will not be sufficient to meet the needs of the ED of 2008. The need for information on which to base better patient care decisions will fuel a tremendous drive to achieve instantaneous remote access to medical record information, wherever it may be located.[14,15] Over time, the adoption of standards in information interchange will allow the single-locus patient database to be replaced by a distributed computerized record, a "virtual" patient record composed of links to information that is stored in various places around the hospital (and around the country). This distributed, or "virtual," medical record is often discussed as though it were a theoretic abstraction, but in fact the distributed medical record is already here.

No patient has all of his or her medical records in one place. A typical patient may have bits and pieces of medical information scattered here and there in medical offices, laboratories, and hospitals across the country. Even if all of a patient's records are at one hospital, they are not all together. Some parts of the complete record are found in the medical records office, other parts in the department of radiology, some in the pharmacy computer, and some in the laboratory computer. Another portion or the record resides in a billing chart in the billing office, part is on a computer in the cardiac catheterization lab, part is on a transcriptionist's computer, and other parts exist in many other places about the hospital.[2] Even today, significant portions of a typical medical record literally have no existence in hard copy. Any billing question, for example, will send a billing representative scurrying not for the chart but for the nearest computer terminal.

Issues of security, privacy, and reliability are raised whenever electronic medical records are discussed, but these issues are neither new nor unique to electronically represented portions of a medical record.[16] Other industries have dealt with these issues for years. Sensitive financial data are shared across portions of the Internet routinely, even though the financial survival of multinational corporations sometimes depends on the integrity and security of these data. Although there have been breaches of security and losses related to electronic banking, it is a matter of record that opportunities for unrecognized financial loss are much greater when manual systems are used to manage and transfer large sums. Over time it will become apparent that the real security issues related to medical records are readily soluble. In fact, many of the concerns that surface in today's discussions of electronic medical records will be recognized as nothing more than expressions of discomfort with something new. The Internet will be accepted as a means of being connected, just as telephones and fax machines have been accepted.

In many hospitals, it is now possible to call up an old ECG record directly on a computer screen.[17] It is technically easy to put that ECG into a password-protected web page and to tell another physician where to point a viewer. When this happens, the two physicians will have created (in a matter of seconds and with no official authorization) an Internet-based distributed medical record, and those responsible for policy and security will be faced with the immediate necessity to address a technical reality that already exists. Today, a physician viewing an ECG across the Internet will probably print out a local hard copy to stay with the printed chart, but by the year 2008 such printouts are likely to seem anachronistic and redundant, since anybody who needs to see the ECG will find it as near as the very nearest computer workstation.

In the ED of 2008, it will not even be obvious which parts of the medical record reside where. The whole system will seem so natural that nobody will think twice about looking at a sonogram from St. Louis alongside a magnetic resonance image from Hong Kong. Within a few years most of the patient's chart will not exist in hard copy, unless an extracted subset has been printed out for a particular purpose. The era of the distributed medical record will truly have arrived.

NEW METHODS—NEW PROBLEMS

Sometimes the adoption of new technologies causes or reveals problems that previously did not exist or were undetectable. The ability to aggregate medical information for large numbers of patients in a single database presents an entirely new class of privacy issues that are distinct from issues related to the privacy of an individual patient record. In a health care delivery system organized around electronically retrievable patient data, the ubiquity of clinical information will force us to address issues that we have been able to neglect under a paper-based system, in which security and privacy are ensured both by the inefficiencies of the system and by locality constraints (the chart exists in only one place, and the place is relatively secure). Although it is fairly easy to gain fraudulent access to a single paper medical record by masquerading as a physician, it would be extremely difficult to gain such access to a thousand medical records at a time. The illegitimate gathering of medical record information by hand, at least on a systematic basis, is simply too tedious and time-consuming to present a serious systematic risk.

Electronic medical records will make it easier for a legitimate caregiver to gain access to the medical chart but will also facilitate illegitimate access to large numbers of medical records on a systematic basis. Even small tidbits of seemingly innocuous medical information can produce a serious risk of abuse when aggregated over an entire population of patients. Traditional security methods are inadequate because ease of access is accomplished only by the loosening of otherwise intrusive security measures. The challenge of the next few years will be to develop new approaches to security that are nonintrusive and do not interfere with legitimate access to records but are still highly effective in preventing illegitimate access. An intelligent security model will require nonintrusive yet absolutely reliable identification of every user before every transaction. Biometric identification systems (such as those using facial, iris, or retinal scanning, fingerprint identification, or hand morphology recognition) offer the most immediate hope for such a nonintrusive yet effective access control screening system.

Improved information browsers will demonstrate to us that more often than was previously realized data on which we depend may be invalid or unreliable. At most hospitals in 1998, patients seen in the ED are registered into a mainframe registration system. Most often, the only mainframe-based view of the data available to ED staff is a single-patient, visit-specific view that must be requested by use of a visit account number. Information in the mainframe system is used principally to drive account-centric billing modules, and there is no easy way to view aggregate sets of information for multiple visits or for multiple patients. It is impossible to visualize patterns within the information that would be suggestive of bad data, and it is usually taken on faith that the information in the system is correct and meaningful.

The adoption of more flexible information interfaces that permit the data to be displayed in different aggregate ways invariably reveals problems with the data that were previously unrecognized. Examples of common problems include duplicate registration, patients registered with different spellings of their names or with different birth dates on different visits, address information that is obviously incorrect or inconsistent, patients registered as uninsured who were verified to have had Medicare coverage earlier in the same month, patients with the incorrect ED physician assigned as the caregiver, and even ED patients incorrectly registered (and billed) as belonging to some other outpatient service. When browsed in the aggregate, with data from multiple visits displayed side-by-side, such patterns of bad information can become immediately apparent.

The adoption of new systems will uncover embarrassing flaws in the underlying assumptions and sometimes in the very analyses that led to the introduction of new technology. Because of a perennial problem with lost and missing x-ray films, one hospital introduced digital radiography and placed viewing stations in the ED. This would seem to guarantee immediate access to all radiographs without the actual film having to be transported to the ED to be viewed and without the problems of lost and absent films. Unfortunately, problems surfaced almost immediately. What had not been recognized in the preconversion analysis was that two independent resources are needed to make clinical use of a radiograph—the single copy of the x-ray film itself and a viewbox with which to view it. In the older, "wet film" setting, the film itself was always the bottleneck. Once the film could be found, there were many inexpensive viewboxes conveniently placed at multiple locations throughout the ED. Lacking a viewbox, the physician could always hold the film up to the ceiling lights for a quick read. In this particular digital radiography system, two viewing stations were installed in the ED, each costing more than $100,000. Since the only way to access a digital radiograph was through the viewing station, this modern "viewbox" became the new limiting resource. Clinicians queued up, each awaiting his or her turn to view films. The anticipated benefit of the digital system, permitting multiple people to view an image without having to search out the film, was lost because of the small number of expensive viewing stations.

The future of emergency medicine will be both "high tech" and "high touch." The core mission of emergency medicine will be the same in 2008 as it is now: to care for patients' unscheduled and episodic medical emergencies and urgencies 24 hours a day, with no limitations as to severity of condition, patient age, type of problem, ability to pay, or existing patient load within the ED. To fulfill that core mission, emergency medicine physicians act along three orthogonal axes of endeavor—processing large volumes of miscellaneous information, performing manual and procedural tasks that require specialized skill and training, and tending to the emotional and human dimensions of their patients. These three axes may be expressed as "thinking, doing, and caring." The physician-patient encounter is mediated in all three domains—the informational, the procedural, and the emotional. If the information about a patient's ED encounter is accurate, legible, up to date, and clearly presented; if the diagnosis is accurate, the treatment correct, and the disposition appropriate; and if all of this has been communicated to the patient and to the patient's personal physician, we will still have failed in our core mission if we have missed the human encounter that is the base of our responsibility to the patient. This is "high touch."

Information technology is the "high tech" component of our future. It will bring about a direct and immediate revolution in the "thinking" domain just by providing a steady diet of the information that supports analysis, synthesis, and decisionmaking. But the greatest byproduct of our new information technology may simply be time to spend with the patient. As physicians we never have enough of the precious space and time we need to exercise our skill and training in procedures ("doing") and to connect with our patients as people in need of succor ("caring") rather than as machines to be repaired. If information technologies can give us back the time we now spend in our "hunter-gatherer" approach to patient information, then it can serve the "high touch" part of our future as well.

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