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Medical Informatics in Neurology

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Updated: Oct 12, 2009

What Is Medical Informatics?

Medical informatics is most simply defined as computer applications in medical care. The definition can be more complicated. Biomedical informatics is an emerging discipline that has been defined as the study, invention, and implementation of structures and algorithms to improve communication, understanding, and management of medical information. The end objective of biomedical informatics is the integration of data, knowledge, and tools necessary to apply that data and knowledge in the decision-making process associated with patient care. The focus on the structures and algorithms necessary to manipulate the information separates biomedical informatics from other medical disciplines where information content is the focus.

According to Van Bemmel, medical informatics comprises the theoretical and practical aspects of information processing and communication based on knowledge and experience derived from processes in medicine and health care.[1,2]

The applications of computers in health care are very extensive, but the field of medical informatics can be structured or divided into the following domains:

- Signal processing - ECG, electroencephalography (EEG), electromyography (EMG) analysis by computer
- Image processing - Radiography, US, CT scanning, MRI/magnetic resonance angiography (MRA), single photon emission computed tomography (SPECT) scanning/positron emission tomography (PET) scanning, cerebral angiography
- Computerized patient records
- Decision support systems
- Telemedicine
- Internet and web-based medical communications

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Signal Processing

Signal processing (EEG, EMG, ECG)

Computers are useful devices for processing electrical signals from various sources, such as ECG for detection of heart dysrhythmias and EEG for analysis and detection of spike and sharp waves that can sometimes be missed by the neurologist.[3,4] The caveat is that many of these systems have a high rate of false-positive results for detection of sharp waves or other

epileptiform discharges that may not be relevant to the clinical situation. As for any automated system, for routine clinical application, computerized EEG evaluation needs analysis by an experienced epileptologist.

In nerve conduction studies and EMG, signal processing with computers can aid in waveform analysis, compound muscle action potentials (CMAP) and sensory nerve action potentials (SNAP) measurements, and amplitude and area quantitative measurements. Combined with a comparison system for reference range values, a custom-made report can be produced for easy recognition of abnormal values and final diagnosis. In general, computerized EMG can help the less experienced neurologist or electromyographer with early diagnosis of subtle EMG changes.

Image Processing

Image processing (radiography, US, CT scanning, MRI/MRA, SPECT/PET scanning, cerebral angiography)

Image processing and pattern recognition are important fields in medical informatics, specifically in neuroinformatics as an emerging domain for CT scanning, MRI of the brain, and other new techniques such as SPECT and PET scanning and functional MRI (fMRI). For example, processing of spatially distributed patterns of brain activation in fMRI data sets using computerized analysis helps determine pathophysiology of many neurologic disorders and define functional structures of the brain.[5,6]

Computerized Patient Records

In the new millennium, information technology will catalyze dramatic change in many aspects of medicine, including patient records. Good medical care requires accurate records of greater detail than in the past. Malpractice protection mandates more organized and complete records. Third party payers are requiring more justification for the expenses generated by physicians' actions. Today's economics require more efficient and cost-effective methods of keeping the patient's clinical records.[7]In 1991, the Institute of Medicine (IOM) released an influential report, *The Computer-Based Patient Record: An Essential Technology for Health Care.* The report advocated adoption of the computer-based patient record (CPR) as standard medical practice.

According to the report, "CPRs and CPR systems can respond to health care's need for a ‘central nervous system' to manage the complexities of modern medicine — from patient care to public health to health care policy." The report described the CPR as a continuous chronological history of a patient's medical care linked to various aids for their user, such as programmed reminders and alerts generated by decision-making systems. The IOM report led to the creation of the Computer-Based Patient Record Institute, an advocacy group that is supported by corporations in the health care, insurance, data-processing, and computer industries, as well as by some professional groups.

The Veterans Administration (VA) medical centers have already adopted this approach by switching to a uniform computer-based records system. This eliminates paper records and allows immediate access to notes and test results, including imaging reports and actual radiographs locally and between facilities. The VA computer patient records system also includes a decision support system that informs physicians about potential drug interactions and appropriate laboratory tests as well as telemedicine support for other centers and consolidation of resources.

Definition of CPR

A CPR is electronically maintained information about an individual's lifetime health status and health care. CPRs are not merely automated forms of today's paper-based medical records but are the first steps toward integrating patient information into the entire scope of health information in all media forms. CPR systems facilitate the capture, storage, processing, communication, security, and presentation of nonredundant health information. CPR systems provide availability of complete and accurate patient data, clinical reminders and alerts, decision support, and links to bodies of related data and knowledge bases. CPR systems can warn a caregiver when the patient has an allergy to a medication being prescribed, can provide the latest research on treatment modalities, and can organize volumes of information about a patient's chronic condition.

Use of CPR

Despite more than 2 decades of research, use of CPRs by physicians is not widespread. In the past 20 years, several systems for the electronic storage of patient data have been developed and used in clinical settings. Early developments involved tasks such as administration, billing, and planning. The early versions of the CPR included categories of patient data that were relatively easy to represent in a structured fashion, such as laboratory data, discharge diagnosis, and medications. The advantages of structured data are obvious: data can be presented in different views and formats, thereby eliminating the need for redundancy. However, the computerized collection of structured progress notes, directly from physicians, was long thought to be unattainable goal. Currently, fewer than 10% of US physicians use a CPR, but enthusiasm for its use is growing.

Among primary care physicians, use of CPRs is gaining popularity. However, usage figures are very low and disappointing with respect to specialists. Several reasons may account for this. Most primary care physicians run a private or small group practice. In contrast, hospital-based specialists work in large institutions in a more complex setting, involving a much larger number of departments and personnel. Therefore, the use of CPR systems has much logistic and financial impact, and stand-alone systems often introduce extra work because they may at best augment, but do not replace, the paper record. Furthermore, because specialists have different medical domains, CPRs should be tailored to their specific needs. Finally, in contrast to primary care physicians, specialists often keep more extensive records, making data entry more time consuming.

Despite these complicating factors, there are many benefits to the use of CPRs in specialized care. Access to multiple sources of patient data, including signals and images, and sharing of patient records can provide a more complete knowledge of the patient and improve the continuity of care.

CPRs or electronic health records (EHRs) are and will be a very important part of medical practice. Recently announced was "The Decade of Health Information Technology," which emphasizes always-current, always-available EHRs for patients. EHRs can improve quality of care, reduce medical errors, and lower administrative costs. Electronic record keeping has the potential to produce savings of 10% of annual spending on health care, while improving care for patients and providing new support for health care professionals. At the same time, the security and privacy of electronic medical records would be improved compared to paper-based records.

Many systems are available and require standardization for ease of use among physicians; many clinicians may need further computer training, so available systems should be designed to decrease administrative work for physicians and enhance the physician-patient relationship.

The IOM has identified a set of 8 core functions that an electronic medical records software system should have:

- Health information and patient data
- Laboratory results management
- Computerized order management
- Decision support system
- Electronic communication and connectivity
- Patient support and education
- Administrative processes
- Reporting

Additionally, the following functionalities help better adoption of the CPR by physicians:

- Transition or flexibility in moving from desktop to handheld computing devices
- Structured data entry to accommodate the diversity of specialized care
- Options to express findings and conclusions in free text or definition of normal
- Graphical data entry for body maps and radiology images
- Automatization and improvement of transcription and upload process
- Enhancement of faxback service and upgrade to electronic file transfer or Web access service
- Enhancement of decision support systems and implementation of artificial intelligence such as drug interaction service and various clinical guidelines

The VA medical system, with the development of computerized patient records, expanded the availability of patient data and images to health care providers. Computerized records ensure that data are available at the point of care and accessible throughout the distributed network of VA and Federal health care facilities where patients are treated. A version of that system called Vista-Office EHR is a new high-quality electronic health record (EHR) system for use in small physician offices; it has been released by the Centers for Medicare & Medicaid (CMS) and is currently under evaluation by different vendors and physician offices across the country.

Vista-Office EHR includes the existing Vista functions of order entry, documentation, and results reporting. It also has been enhanced in the areas of physician-office patient registration, interface possibilities to existing billing systems, and reporting of quality measures.

Decision Support Systems

Decision support systems are real-time computerized algorithms that help physicians in their clinical practice. For example, when clinicians perform a task (eg, order entry) using the CPR, they are warned if the task appears to be inappropriate on the

basis of patient data. The system presents this warning automatically using consensus-based clinical decision support "rules" that are derived from medical knowledge (or financial data) and patient-specific information.

For example, EMG expert systems such as EMG Assistant can help electromyographers through a sophisticated analysis of the input data and provide them with the most likely diagnosis that objectively best explains the findings. These programs can help doctors understand the readings as they develop the field experience to analyze the data themselves.

Telemedicine

Telemedicine is distance consultation among health professionals or between health professionals and patients by use of telecommunications technology such as real-time audio or visual systems, most notably video conferencing. The potential advantages are obvious in dispersed communities, where expertise is thinly spread, and when traveling is difficult or inconvenient for doctor or patient. Uses are wide and varied and include direct interview and history taking, observation of physical signs, and distance reporting of imaging procedures. The location of consultation varies from hospital inpatient and outpatient settings, to broader residential and home settings, and even outer space.

Some hospitals in the United States are using broadband technology to improve patient care and cope with a national shortage of physicians in certain specialties. For example, in one hospital in California, patients in the intensive care unit (ICU) are monitored by doctors a mile away in a control room called the eICU. With advancing communications protocols, neurologists can view their patients' radiology images and diagnose their diseases from remote locations. Even computer-assisted neurosurgery is possible.[8]

Prescription improvement packages offer physicians a wireless handheld electronic prescribing unit, a wireless access point, and a 1-year subscription to an e-prescribing service. This allows physicians to discard their prescription pads in favor of electronic transmissions to any pharmacy. A recent report by the Foundation for eHealth Initiative estimates that nationwide implementation of e-prescribing could save the US health care system $29 billion a year.

Another convenient and cost-effective use of telemedicine will be in teaching and consulting situations, especially when large distances separate educator and learner. In areas of the country where patients are long distances from a medical center or when transportation is a problem, such systems will be very helpful.[9]

Recently there has been growing interest to obtain state and JCAHO certification to establish stroke centers in the hospitals across the country. Unfortunately, many of small hospitals lack the professional expertise and necessary equipments to deal with complicated stroke patients. The Telestroke program initiative may help the hospitals in this regards.[10]

By establishing a telemedicine link using videoconferencing and image sharing technology, stroke specialists from major academic centers can help ER physicians in rural or satellite areas to administer tPA and guide them for the best treatment that can potentially saves many lives and reduce stroke morbidity and disabilities.

Telemedicine will not be easily accepted by physicians as a routine substitute for direct patient care because it lacks the

intimacy of face-to-face conversations, but it is an exciting and beneficial addition to the world of healthcare. More of it will undoubtedly be available in the near future.

Remember that communicating with patients through email is prudent only if the following guidelines are employed:

- Establish turnaround time for messages and do not use email for urgent matters.
- Inform patients about privacy issues.
- Establish types of transactions (eg, prescription refill, appointment scheduling) and sensitivity of subject matter (eg, HIV status, mental health care) permitted over email.
- Instruct patients to put the category of transaction (eg, prescription, appointment, medical advice, billing question) in the subject line of the email message for filtering.
- Request that patients put their name and patient identification number in the body of the message.
- Configure automatic reply to acknowledge receipt of messages.
- Print all messages, with replies and confirmation of receipt, and place in patient's paper chart.
- Send a new message to inform patient of completion of request.
- Request that patients use autoreply feature to acknowledge reading provider's message.
- Maintain a mailing list of patients but do not send group mailings where recipients are visible to each other. Use the blind courtesy copy feature in email software.
- Avoid anger, sarcasm, harsh criticism, and libelous references to third parties in messages.
- Consider obtaining patient's informed consent for use of email.
- Never forward patient-identifiable information to a third party without the patient's express permission.
- Use encryption for all messages when encryption technology becomes widely available, user-friendly, and practical.
- Do not use unencrypted wireless communications with patient-identifiable information.
- Commit policy decisions to writing and electronic form.

Internet and Web-Based Medical Communication

Despite the tremendous growth of the Internet and the vast amount of information available to medical practitioners, busy physicians (especially those in clinical practice) have little time to spend exploring the Internet. In some cases, physicians simply do not know how to access required medical information in the best and fastest possible way. Many physicians do not know how beneficial the Internet can be for their medical careers, especially in such areas as patient care, academic work, or research.

The Internet has attracted considerable attention as a means to improve health and health care delivery, but how prevalent Internet use is in health care or what impact it has on health care utilization is not clear. Available estimates of use and impact vary widely. Approximately 40% of respondents with Internet access reported using the Internet to look for advice or information about health or health care in 2001. Six percent reported using email to contact a physician or other health care professional. About one third of those using the Internet for health reported that using the Internet affected a decision about health or their health care, but very few reported impacts on measurable health care utilization; 94% said that Internet use had no effect on the

number of physician visits they had; and 93% said it had no effect on the number of telephone contacts. Five percent or less reported use of the Internet to obtain prescriptions or purchase pharmaceutical products.

An increasing proportion of the public is using the Internet for health information. This is expected to have a profound effect on medicine, but whether this effect will be beneficial or harmful is unclear. The advantages of the Internet as a source of health information include convenient access to a massive volume of information, ease of updating information, and the potential for interactive formats that promote understanding and retention of information. Health information on the Internet may make patients better informed, leading to better health outcomes, more appropriate use of health service resources, and a stronger physician-patient relationship.

However, health information on the Internet may be misleading or misinterpreted, compromising health behaviors and health outcomes or resulting in inappropriate requests for clinical interventions. Physicians may accede to inappropriate requests, either because refusal is time consuming or because they fear refusal would weaken the physician-patient relationship. Responding to inappropriate patient requests may be particularly difficult in managed care, where patients may believe that physician refusals may be motivated by the need to control costs.

More-informed patients often have a more favorable prognosis, and doctors can help make patients better informed by supplying reliable Internet sites. Researchers at University of Iowa tested the benefits of an "Internet prescription," or a list of Web addresses containing information relevant to patients' medical conditions. In the study, patients and their families that received such information were more likely to use the Internet to find health information than patients who were not. One of every 3 parents receiving Internet prescriptions for their child's health said they used it. Also, 66% of the health-related Web sites used by parents in the prescription group were sites recommended by the physicians.

Physicians can access professional Internet sites for the following purposes:

- Access/maintain patient records
- Blogging
- Complete CME credits
- Information on clinical trials, message going to consumers/patients
- Information on medical equipment/devices
- Information on medication/procedures
- Interactive learning
- Medical discussion groups (eg, Sermo, peer-to-peer social networking)
- Meeting/conference information
- Patient information/educational materials
- Medical news, journal
- Research specific clinical situations and read medical books
- Webcast/podcasts

In conclusion, the Internet and Web has had important impact in the practice of medicine. Physicians need to know the importance of this media and how to use it in a pragmatic and efficient way. Many physicians believe that they save personal

time by using the Internet and that they can use the Internet for better practice of medicine. They can have easy access to clinical guidelines, journal contents, and reference textbooks and even provide patients with educational materials. Physicians will be able to obtain information on state-of-the-art conferences and have direct communication with other physicians and specialists or practice telemedicine, thereby expanding the depth and extent of medical knowledge and providing better diagnosis and patient care.

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Keywords

signal processing, image processing, decision support systems, computerized patient records, computer-based patient record, CPR, telemedicine, telestroke, electronic health record, EHR, Web-based CME, computer applications in medical care, computerized patient care, biomedical informatics, computer applications in health care