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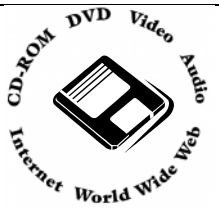

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A Model for Real Time Information at the Patient's Side Using Portable Computers on an Acute Pain Service

Health care professionals and patients could benefit immensely from easy and timely access to patient records and evidence-based resources. Handheld computer technology with wireless capability makes this a possibility. Computerized patient records (CPR) can be accessed to provide accurate, timely, and concise information, to influence treatment decisions. Evidence-based resources could be made available on a personal digital assistant (PDA) in the form of textbooks, journal abstracts, and clinical practice guidelines formatted for PDAs. This article will present the conceptualization and development of a computerized model for use by an acute pain management service (APMS), using hand-held technology linked to an application server (AS) to provide near real time (batch) and real time radio-frequency (RF) information at the bedside.

Health Care Informatics Background

CPRs currently exist in the health care setting primarily in the form of the hospital information system (HIS). To a lesser extent, point-of-care tools have been developed and implemented in the form of clinical practice guidelines and alerts. These are conveyed to the physician when data entered into the system are inconsistent with established parameters.[1,2] Implementation of these real-time systems has been found to enhance the diffusion and adoption of clinical practice guidelines and has had a positive effect on practice outcomes.[1,3,4] Adoption has been poor, primarily due to the lack of infrastructure required to support these systems in most hospitals.[5] However, with the introduction of PDAs and wireless technology into the health care setting, an opportunity exists to bring real-time information to the patient's side. An industry report indicates that by 2004 20% of physicians will be using PDAs in their practice.[6] These devices can streamline the flow of information by allowing nurses and physicians to access a patient's complete history, know the most current status, and check doctors' orders while at the bedside.[7] "Wireless technology can introduce a new level of quality in patient care. Point-of-care technologies increase the mobility, even beyond the confines of the hospital, of caregivers documenting treatment and using information throughout the healthcare facility. Patient information can go directly to the CPR/HIS, enabling real-time patient management".[7] Additional benefits include standardization of documentation, improved compliance, and increased record access, reporting capability and accountability. Problems such as charting timeliness, order tracking, prescribing, drug errors, and data collection can also be addressed.[7,8]

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The Specialized Requirements of Acute Pain Management Service Informatics

Given the advantages of adopting PDA and wireless technology in the health care setting, a model for real-time information at the patient's side was conceptualized for use in postoperative pain management. The management of acute pain postoperatively has been recognized as a multifaceted, complex process. Studies have shown that age,[9] gender[10,11] patient size,[9] psychological factors,[12,13] culture,[9] history of substance abuse,[9] site of surgery,[9] previous pain experiences,[14] and anesthetic type[9] all have an impact on how the patient will respond to acute pain and the treatment of that pain. Improperly managed acute pain can lead to adverse outcomes, such as, myocardial infarction, stroke, pneumonia, and chronic pain.[15] In addition, attention to side effects from therapy, such as respiratory depression, sedation, delirium, renal insufficiency, liver failure, constipation, dyspepsia, pruritus, and nausea and vomiting and side effects of the treatment of these side effects must be incorporated into acute pain therapy in order to achieve optimal response.

A model for the management of acute pain was first proposed by Ready.[16] The success of which depends upon a continuous quality improvement (CQI) program that includes ongoing assessment and evaluation of treatment modalities.[16,17] A recent survey indicates that variations of the model have been incorporated into academic hospitals across Canada.[18] Data collection is an integral part of most APMSs, however, only 32% of centres collect and use ongoing data and of those who do, only 33% have computerized the process.[18] The traditional paper method approach to patient records results in widely varied and frequently inconsistent or inadequate information, and is not conducive to ongoing data collection. Yet given the complexities involved in acute pain management, nurses and physicians have a need for specialized timely information to assist in the clinical decision-making process. For these reasons the development of a computerized model was undertaken.

The intended users of the APMS software and database are clinicians (physicians and nurses), researchers, and administrators. Acute pain clinicians and pharmacists will have access to patient information at the bedside to assist in clinical decision-making and to provide an ongoing database to assist in monitoring CQI indicators. Access to large databases will facilitate research in quality care issues, including the development of pain and side effect profiles for acute pain patients. The data will also provide important information for the development of evidence-based clinical practice strategies about the management of acute pain. These tools will also be used to study the effectiveness of the service. Administrators will have access to timely, standardized reports to assist in decision making about allocation of resources.

The following section will describe the architecture of the proposed model, followed by a clinical example where the data collection process will be described in three ways: 1) using the traditional (current) paper method; 2) using a PDA with *batch* processing of data with the AS and the HIS; and 3) using wireless data exchange with *RF* between the PDA, the AS and the HIS. The latter two processes will provide near real-time or real-time information at the bedside. The original impetus for the project stemmed from a desire by anesthesiologists to have a feedback mechanism in place to provide more comprehensive information about pain therapy.[19] The goal of the project was to provide accurate, timely, and concise information, to influence decisions about the treatment of acute pain during the preoperative, intraoperative, postoperative and discharge period. Information relating to all aspects of pain management and side effect profiles will be collected and made available at the point of care with the aid of PDAs. The information will then be used to make evidence-based decisions about patient care. The electronic database, as well as the effect of having such data available at the bedside will provide important information for research into the development of evidence-based clinical parameters, and the effect of the availability of these parameters on clinical decision-making. The electronic database will also contribute important information to administrative reports and decisions regarding resource allocation.

Architecture of a Model for Real Time Information at the Patient's Side

As indicated above, information used in the treatment of postoperative acute pain is complex and is obtained from several sources. All aspects and stages of patient care related to acute pain were incorporated into the development of the model. These include:

To identify components of an ideal acute pain assessment.

To identify components of an ideal anesthesiology preoperative consultation.

To review technology options for portable computing and to decide which system is ideal for data collection. Variables include cost, weight, battery life, and ease of use, screen size, synchronization capability (batch or RF), and durability.

To write the functional specification for the interfacing hardware and software to support the hand-held device, which includes querying the HIS regarding the patient's location, laboratory, pharmacy, imaging and other diagnostic test results, and consultations with other specialties.

To draft the PDA screens to facilitate accurate and timely data-entry by clinicians who may have limited computer experience.

To utilize existing local area network (LAN) infrastructure to connect the hand-held device to the AS.

To introduce RF and PDAs which interface with the HIS. Thus giving the clinician the ability to review laboratory, imaging, pharmacy, and electrocardiogram results, and therapeutic information to assist in clinical decision-making at the bedside.

To incorporate a system to reduce drug error through the use of bar codes on patient's health information records, identification bracelets and drugs packaged by pharmacy.

To identify clinical problems using the PDA.

To form a national acute pain network/database through establishment of the model in other hospitals and the creation of an online data link to facilitate data collection and research.

When fully operational, the national acute pain database will have many facets. It will incorporate information pertinent to the treatment of acute pain obtained during the preoperative assessment in the anesthetic consultation clinic or upon admission to the hospital. The preoperative assessment, which is currently dictated or written on the chart, will be recorded on a PDA or personal computer (PC) using proprietary software to interface with the APMS database. Information believed to be important to the patient's perception of pain and the physician's ability to treat pain will be stored on the database. This includes the general history and physical findings, and specific information regarding allergies, pain, dyspepsia, constipation, medications, sleep habits, anxiety, depression, and drug, alcohol, caffeine, and nicotine consumption. As tests are performed they will be entered into the system. Any acute pain therapy initiated during the perioperative period and data obtained while the patient is being followed postoperatively by the APMS will also be recorded on the APMS database. While on the APMS the patient interview will become more comprehensive, as physicians are given queues to request information such as pain assessments, sedation, nausea, vomiting, pruritus, status of catheter insertion site, and motor and sensory block. The data from the PDA will be synchronized with the APMS database and will be available to clinicians looking after the patient. As the model evolves, patient information such as, cardiac, respiratory, central and peripheral nervous system, and renal status which are important components of evidence-based clinical decision-making, will be available when making decisions about epidural, patient-controlled analgesia (PCA), peripheral nerve blocks, and non-steroidal anti-inflammatories (NSAIDS) use. Preliminary tests indicate that assessments using the PDA are shorter, yet more comprehensive than the traditional paper method, and more time is spent interviewing the patient rather than recording the assessment.[20]

As the system is currently being developed, all information can be entered into the PDA utilizing check boxes and drop-down lists. Many aspects such as the patient history will in the future be linked by wireless technology to the CPR. Currently family physicians can access some aspects of patient care via the HIS, but information such as pain therapy and discharge summaries are not available in this format. With the implementation of this model, both surgeons and family physicians, through the CPR, would have access to information about acute pain therapy during the hospital stay, including response to pain therapy and development and treatment of side effects. It is anticipated that data availability will become more comprehensive. Future plans for the model include incorporating an automated anesthetic record keeper and eventual evolution into a complete perioperative network.

Application of the Model to an Acute Pain Management Setting

The following example depicts how a patient currently flows through the perioperative period (Figure 1), how that patient would flow through the same period using the batch system (Figure 2) and the wireless system (Figure 3). Currently the patient is admitted to the hospital through the patient registration office, the same day admission clinic, or the emergency room (ER) (Figure 1). A written preoperative assessment is completed by the anesthesiologist in the preoperative anesthesiology consult clinic, the same day admission area or the ER. During the assessment, the anesthetic and strategies for pain management are discussed with the patient.

In the operating room (OR), the pain treatment modality is selected and orders are written by the anesthesiologist, including the pre-selection of drugs to

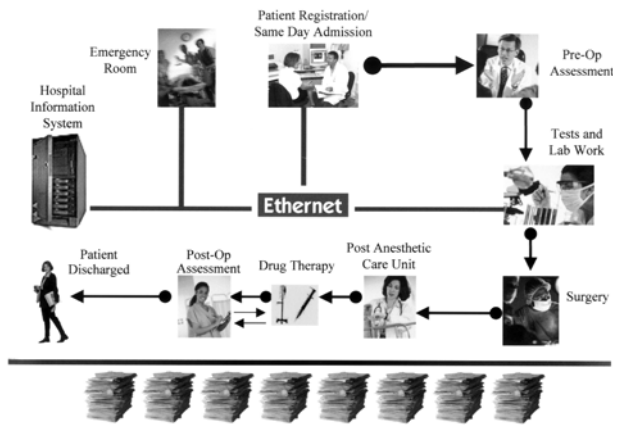

FIGURE 1 Acute pain management service visit cycle - current mode.

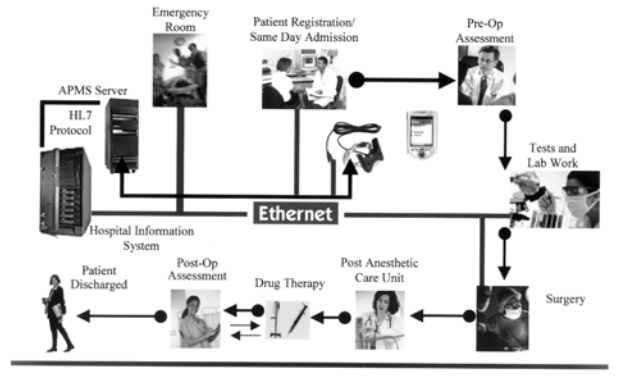

FIGURE 2 Acute pain management service visit cycle - batch mode.

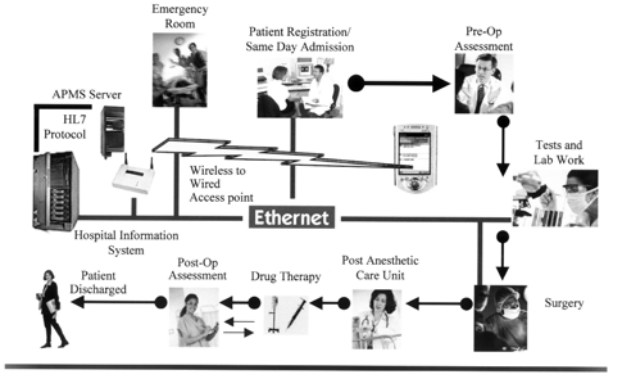

FIGURE 3 Acute pain management service visit cycle - radio frequency mode.

treat possible side effects from therapy. The documentation involved includes completion of the pain order sheet, the side effects order sheet, the MD flow sheet and the RN flow sheet. The RN flow sheet remains at the patient's bedside for RN documentation while the patient is on the APMS. The pain and side effects order sheets provide information about pain and side effect therapy. The MD flow sheet provides a brief surgical history and APMS daily progress report for the APMS anesthesiologist. The MD flow sheet is put in a binder by the postanesthetic care unit (PACU) nurse in the PACU for the acute pain physician to pick up prior to patient rounds. The remaining 3 sheets are put in the patient's chart. Upon arrival in the PACU the PACU nurses record the patient's pain on the RN flow sheet. The PCA/epidural is established (if ordered) if not already initiated in the OR. Once alert, the patient is asked about level of pain, using a pain assessment scale, and side effects of therapy. Information regarding vital signs, opioids given, nausea and vomiting, sedation, respiratory depression and extreme motor and sensory block is recorded. Based on the response to these questions the patient may be given more narcotics or have their analgesic therapy reviewed by the anesthesiologist. Once the patient is awake and oriented, with pain scores < 4 at rest and < 6 with movement, they are discharged to the ward. Prior to discharge from the PACU, the patient is re-educated about the use of the PCA or epidural pump and the pain scoring system.

While on the ward, the patient's pain is reassessed at least every four hours (more frequently initially) by the bedside nurse and recorded on the nurses' flow sheet at the bedside. Members of the APMS team, which includes an anesthesiologist and a nurse clinician, usually perform daily patient rounds on all patients and more often on new admissions and patients requiring therapy changes. On APMS rounds the pain scores are reviewed and side effects may be assessed and documented by the anesthesiologist on the physician flow sheet and the physician progress notes. Assessments on APMS rounds are also recorded by the nurse clinician on the nurses' flow sheet at the bedside, and possibly on the nurses' progress notes. If new strategies are initiated to further reduce pain and side effects these are also documented in the above-mentioned documents as well as on the physicians' order sheet. Once the patient's pain is controlled with oral analgesics in the days following

surgery the patient is usually discharged from the APMS with a suggested pain treatment plan, and is followed by the primary surgical service.

In addition to being labour intensive, the main disadvantage to the approach described above is, duplicated, inadequate, illegible and/or misplaced documentation, resulting in diminished continuity and quality of care. The current method of accessing much of this information is through manual chart audits. The introduction of computerized technology into health care delivery provides a unique opportunity to streamline this process and to provide accurate, timely, accessible and concise information in a digitized format for clinical, administrative and research purposes. A diagrammatic representation of the proposed model using batch processing can be found in Figure 2.[21]

The patient would follow the same route as described in Figure 1. However, in the preoperative consult clinic, the same day admission clinic, or the ER an armband with a bar-coded label would be issued at the admission desk. The preop assessment would be documented on a PC, tablet, or PDA using a standardized format, which complements that of the existing anesthetic record. After the history and physical examination results are recorded on the PDA, the information is uploaded via synchronization, to the APMS AS. Upon completion of the preop assessment and review of laboratory and consultation notes, the risks of anesthesia and the pain strategies are reviewed with the patient and documented on the patient's chart.

In the OR the patient armband is scanned using a braced scanner tethered to the OR PC. This documents the time and date of OR entry, recalls the demographic data, preop assessment and laboratory results from the AS, populates the anesthetic record with this information and prints the record. In the OR the anesthesiologist completes the physician order sheet, nurses' flow sheet, the pain order sheet and side effects order sheets on the PDA or PC. After synchronization, the records are printed in the PACU and/or placed on the chart to be sent to pharmacy upon arrival on the ward. As a paper backup, the records are filed in the physician binder and the patient chart.

Each morning prior to rounds clinicians (MD/RN) synchronize their PDA with the APMS AS. On a continuous basis the AS receives updated patient information from the HIS, including laboratory, imaging, pharmacy and electrocardiogram results, thereby ensuring the most up to date information is available to the clinician on the next synchronization. The list of acute pain patients is downloaded to the PDA with an up-to-date list of all patients on the service, their location, a summary of their orders, latest assessment, and laboratory results. In the PACU/ward a new assessment is initiated by scanning the patient's armband to identify the patient and display the patient's most recent details on the PDA. A new assessment may be entered into the PDA, which includes an evaluation of the patient's level of sedation, pain scores, side effects and PCA pump utilization (e.g., total amount of opiate used). The PDA is also populated with information regarding side effects of APMS therapy. If a new side effect treatment is needed it is ordered using the PDA. Upon completion of the assessment and orders the information is beamed to an infra red compatible printer and assessment summaries and new orders are printed on sticky labels to be placed on the chart. At the end of each ward assessment or the end of morning rounds, the PDA is synchronized with the APMS AS, which uploads to the AS new orders and downloads new patient information to the PDA in preparation for the next patient rounds. The above model provides near real-time information at the bedside and is based on collateral use of electronic and paper records allowing for a gradual integration to a paperless system. In summary, the batch system using a PDA and bar code technology, would allow for prompt point-of-care data access and entry, including order entering, near real-time information at the bedside, and the ability to generate routine reports and to query the system for specific information.

The ultimate goal in developing point-of-care systems is to have access to real-time information to assist in evidence-based clinical decision-making at the bedside. The combination of hand-held and wireless technology as depicted in Figure 3 achieves this goal. The flow through the system would not be altered, however periodic synchronization would no longer be necessary and querying of previous assessments on the PDA would be possible, thereby allowing for data trending. Data such as laboratory and imaging findings would be received and reviewed in real-time. Evidence-based alerts could be incorporated into the existing software or accessed online, to further assist in clinical decision-making. Collateral paper records could be maintained as indicated in the batch model to allow for gradual integration to a paperless or near paperless model.

Conclusion

This article focuses on the development and application of a model for real-time information at the patients' side in an APMS setting. The model would provide relevant patient information and evidence-based clinical practice guidelines and alerts at the point of care. The computerized data resulting from the model would provide valuable information for

researchers, clinicians, and administrators to assist in improving quality, effectiveness and efficiency in the health care setting. The clinical application of this model for acute pain management has the potential for a broad application within health care delivery.

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