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Electronic Monitoring in an Acute Pain Management Service

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ABSTRACT

Objectives. This article will address the process involved in the development and implementation of a clinician-driven portable electronic chart on an Acute Pain Management Service (APMS). We describe the latest version of the program and provide 1 year of clinical data.

Setting. Tertiary care center in Kingston, Ontario, Canada.

Patients. All patients admitted to the APMS between August 1, 2005, and July 31, 2006.

Results. A total of 8,726 APMS visits were made to 2,528 patients. Mean length of stay on the Service was 2.3 days. Sixty-one percent of patients reported an active pain score >3/10. Pain scores were highest with hip or knee surgery. Thirty-five percent of patients reported nausea.

Conclusions. Executive sponsorship, alignment with institutional priorities, and user input are essential to the development, implementation, adoption, and sustainability of an electronic patient record. Ready access to data at the bedside can improve quality of care, while ongoing, comprehensive data can contribute to Phase IV drug trials. Incorporating both clinical and research outcomes in the database improves data quality and usability, but must be balanced with the impact of clinical time constraints on documentation. Wireless technology and Tablet computers provide portability and adequate screen size for documentation and reviewing of patient data on an acute pain service. It is necessary to provide solutions to process issues, such as printing electronic records during the transition from paper to electronic records.

Key Words. Acute Pain Service; Electronic Patient Record; Health Informatics; Computers; Research; Postoperative Pain

Introduction

Wireless technology and portable computers, which are widely used in other industries, are being developed for the management of health information with data capture at the point of care. The introduction of information technology into health care provides a unique opportunity to improve and expand clinical, research, and administrative information systems. The advantages of portable computers are their relatively low cost, their portability and unobtrusiveness, and their ease of data sharing [1]. Access to electronic patient data on portable computers at the bedside provides clinicians with up-to-date patient information on the process and outcomes of care, thereby facilitating evidence-based clinical decision making [2,3]. Additionally, up-to-the-minute outcomes data contribute to timely continuous quality improvement and safety monitoring, and research, administrative and policy initiatives [4–7].

Models for the development and implementation of electronic data capture for pain have been reported [8,9]. Studies reporting electronic documentation on an Acute Pain Management Service (APMS) are primarily based on the use of handheld computers for documenting patient assessments. Efficiency and satisfaction with electronic

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documentation of acute pain assessments is generally reported as being comparable to paper-based assessments, while data completeness is generally better with electronic documentation [3,10–12]. Pain assessment data captured using handheld computers are also reported as being comparable to data captured using pen and paper [13].

Factors compromising the development of a universal electronic data capture tool for use on an APMS include the variability in organizational structure, setting, and clinical practice patterns [9,10,14]. In a Canadian survey of directors of APMS, we found that many reported not using electronic data capture and of those who did, few used the data for ongoing quality assurance or research purposes [15]. The Canadian Collaborative Acute Pain Initiative recommended guidelines for the structure and process of an APMS, including the need for electronic data capture, a minimum dataset, and a national database which could act as a repository for acute pain data [16]. From these initiatives, as well as clinical studies assessing the structural and attitudinal barriers toward electronic data capture [3,10,17], we developed an electronic system for use on our clinical service. This article will address the process involved in the development and implementation of a clinician-driven portable electronic record on an APMS in a Canadian tertiary care hospital. We describe the latest version of the program and provide 1 year of clinical data.

Rationale

The awareness and integration of clinical management and research outcomes is an essential first step in the process of developing an electronic patient care system for use at the point of care. A review of the successes and challenges of the process undertaken by the APMS in one academic health sciences center will provide a useful illustration of development considerations. The ideal APMS solution allows the perioperative team to add a patient to an APMS patient list, identify the nursing unit and bed number where each patient is located, review the latest diagnostic results, study notes from prior APMS admissions, record a standardized pain assessment and plan of care, and abstract data for quality improvement and research purposes. Realization of this ideal requires executive sponsorship to enable integration of an APMS computer solution with a hospital computer enterprise, while addressing security, privacy, adoption, ethical and sustainability issues.

History and Operations

The majority of acute pain patients begin the consultation process in the operating rooms. As the development of a formal APMS, we tried several methods to achieve the following: 1) record a request for an APMS consult by the operating room Anesthesiologist/Surgeon; 2) review relevant diagnostic test results and clinical information from prior APMS admissions; and 3) record the results of acute pain patient assessments, care plans, and notable or unexpected events. The current electronic application, APMS Version 4.2, has undergone a systematic evolution over the past 7 years. During this time, the hospital has operated with a paper-based patient record for clinical documentation. As a result, the original APMS consult request form was in paper format. This form was kept in the postanesthetic care area and was used to provide information such as the patient's pain history, comorbidities, and location in the hospital. It provided a quick overview of the pain management history during the perioperative and postoperative period. An APMS patient list provided on the hospital intranet was added to the paper consult, and allowed the APMS to readily locate patients using any computer in the hospital. When the first APMS software was developed for use on Palm Computers, the patient list on the hospital intranet could be downloaded to the Palm. Upon synchronization with the APMS database, electronic information such as the patient list, laboratory results, and past APMS assessments could be downloaded to the Palm, while new assessments could be captured on the Palm and uploaded to the APMS database. In 2001, a wireless infrastructure was implemented in the hospital, the software was upgraded for use on a Windows Operating System, and several personal digital assistants (PDA) were trialed, including the Toshiba, Dell, and Compaq iPaq. The Compaq iPaq was finally selected due to its durability, extended battery life, reasonable cost, and superior wireless capability. After careful review, including extensive feedback from clinicians, we upgraded the software to APMS Version 4.2 and switched from the Compaq iPaq PDA to Tablet Computers to satisfy the desire by clinicians for a large screen area. We trialed Tablets manufactured by IBM, Toshiba, and Motion Computing. We are currently using the IBM Tablet because it is supported by the hospital Information Technology Service. Given that the patient record continues to be paper, APMS

assessments are printed and placed on the patient record.

The APMS system currently uses 802.11B triple des encryption, which is the standard used in banking institutions and exceeds the encryption standards in most health care institutions. We have real-time access (i.e., data are available to APMS as soon as they are available on the patient care system) to patient demographics, bed location, surgical procedure, medications dispensed by pharmacy, and investigative results (including laboratory, imaging, and electrocardiogram).

Details of the APMS Application Currently in Use

The current APMS system has been adopted as the clinical application for the APMS. All clinicians on the service, which includes anesthesiologists, trainees, and the advanced practice nurse, use the device to record patient assessments. The main components of the APMS program are the: 1) patient list; 2) summary; 3) modality; 4) side-effect therapy; 5) assessment; 6) drug usage; 7) plan; 8) notable events; 9) consult; 10) study; 11) notes; and 12) billing. APMS consults are entered into the APMS application via the hospital intranet. The operating rooms and all nursing units have desktop computers at accessible stations. Typing "APMS" into the address bar on the hospital intranet accesses the APMS web application. The user then logs in with a user name and password, which brings up the APMS patient list (Figure 1). An administrative tool bar is present across the top of each APMS screen and a series of tabs that primarily relate to patient care appear along the left side of each screen. The adminis-

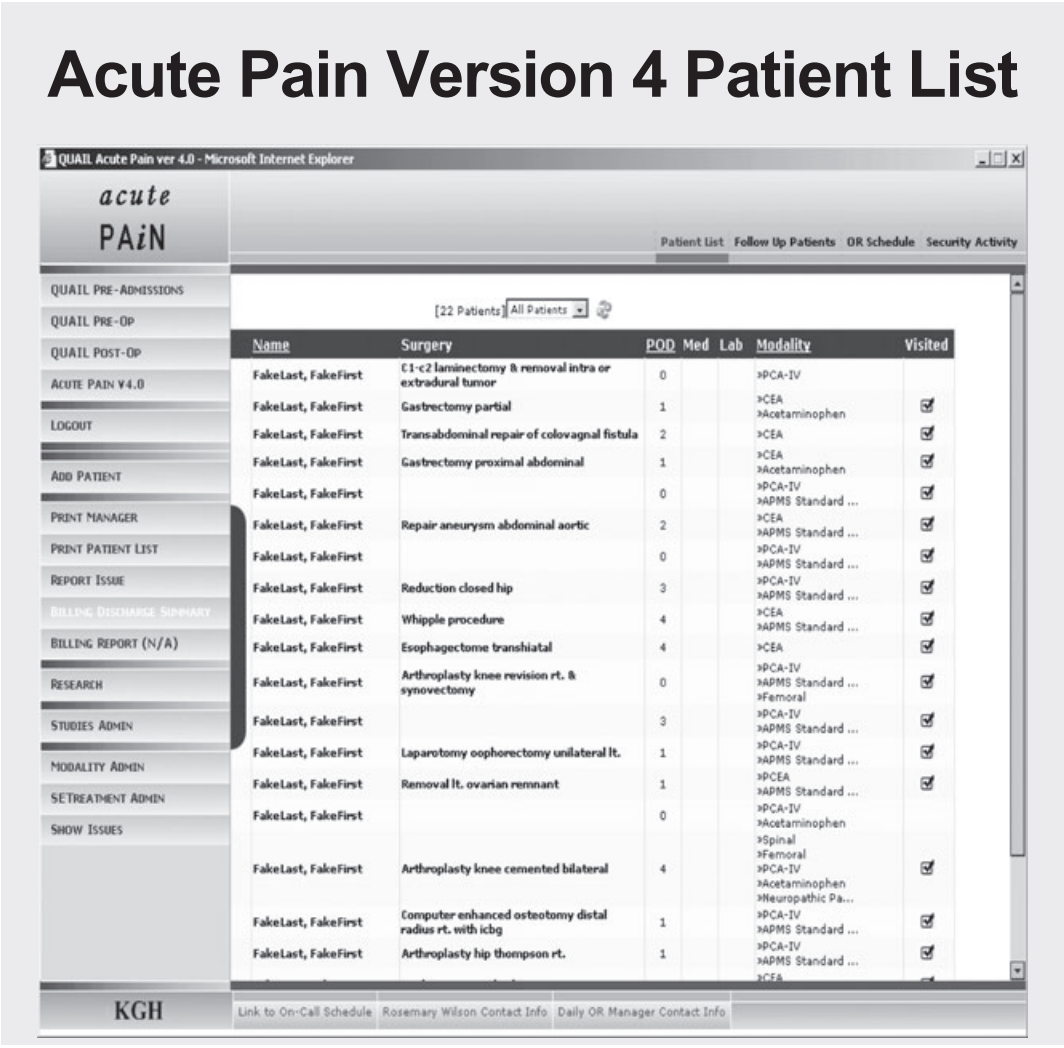

Figure 1 Example of Acute Pain Management Patient List screen.

trative tool bar has several features including: 1) "Follow-Up Patients" who are patients identified on morning rounds as requiring an afternoon visit by the APMS; 2) "OR Schedule" which provides information to the APMS for planning the insertion of blocks preoperatively; 3) "Security Activity" which tracks access to the APMS system; and 4) "Billing" identifies the agency paying for the care. The 16 tabs down the left side of the screen include patient care data such as surgical history, assessment findings, notable events, a plan of care, as well as the ability to print the assessment, add or remove patients, and view billing information.

The *patient list* screen provides the patient's name, location, surgical procedure, postoperative day, medication or laboratory clinical alerts (e.g., alert will appear if incompatible medications have been prescribed or investigative results are abnormal), pain modality, and a "visited" box. The latter is checked after each patient visit by the APMS. The operating room Anesthesiologist enters a patient to the APMS list by clicking a side tab found on the left of the screen called, "add patient." This allows the user to enter the patient to the list. The interface with the hospital information system provides the room number, the surgical information, and clinical alerts. The operating room scheduling software provides the surgical procedure information. For emergency procedures, for which the surgical scheduler software has no surgical procedure information, the user types in the procedure and identifies with a drop-down box, the surgical subspecialty. The user is then asked to record whether the consult is for acute, chronic or palliative assessment and any pertinent comorbidity information.

When a patient's name is selected on the patient list, all subsequent screens provide the patient's name, age, unique identifying number, room number, and surgical procedure. The *summary* screen provides the surgical procedure and the postoperative day (day of surgery is day 0). This guides the APMS clinicians (nurse or physician) in terms of expectations of pain and interpretation of the total amount of drug used by the patient. The drug name, modality, and amount of drug used are recorded by the clinician utilizing drop-down boxes to facilitate consistent entry of information by all users. The lists include common therapies, drugs, and an extensive list of nerve blocks. The user may record the type of block implemented, the drugs used, whether a catheter was introduced and any special notes about the procedure. Medication and laboratory clinical alerts appear in the form of a red dot next to the patient's name.

The patient *assessment* screen includes 21 variables with lists that drop down when a variable is selected. If the drop-down list does not include a relevant option the clinician has the option of using the keyboard or stylus to write a message in the text box, or record a voice message using the speaker software. Variables included in the APMS assessment screen were selected based on several studies, as well as user input [3,8,10,15,16]. Clinicians have the option of recording pain scores using a numeric rating scale (NRS) or as free text; however, most clinicians record the former. This APMS tool is designed such that the user may add new pain scales or qualifiers and the tables of the relational database will automatically be created. Patients are usually asked to report their pain when moving (i.e., active) or at rest. This differentiation is made to identify whether the patient is able to deep breath, cough, and ambulate. The ability to perform these activities decreases the potential for morbidity and delayed discharge from hospital. If a response exceeds a set limit (i.e., pain score greater than 5), a note stating "inadequately treated pain" is automatically displayed. The notable event screen presents 20 possible options, including intractable nausea, vomiting, and pruritis, as well as epidural catheter, pump-related problems, and drug-related errors. A narrative record can be included with each option selected.

The *plan* screen provides 18 options for planning patient care. Some examples include: reorder of medications, change or addition of pain modality, or hold morning heparin. Each option includes drop-down boxes for responses, as well as the ability to provide a narrative. A *notes* option on this screen provides an additional opportunity to record an issue which was not listed in the assessment drop-down boxes. A research function captures whether a patient is part of a particular study. The clinical trials group in the Department of Anesthesiology uses the APMS software to track study patients, to monitor pain assessments, and to display study protocols. A reporting tool allows for the reporting of technical issues or suggestions for the removal or addition of variables.

Results of One Year of Electronic Data Capture on an APMS

A total of 2,874 patients were admitted to the APMS from August 1, 2005, to July 31, 2006. The

Table 1 Numeric rating scale pain scores reported by elective patients admitted to the Acute Pain Management Service postoperatively between August 1, 2005, and July 31, 2006 (N = 2,208)

		Mean NRS (SD)		NRS > 3/10		NRS > 5/10	
Pain Scores	No. of Patients	Rest	Active	Rest (%)	Active (%)	Rest (%)	Active (%)
All assessments	2,208	1.7 (2.0)	3.6 (2.6)	28	61	12	35
Postoperative day 1	2,020	1.9 (2.1)	3.9 (2.6)	21	53	7.6	28
Postoperative day 2	1,280	1.4 (1.8)	3.4 (2.4)	14	45	4.1	20
Postoperative day 3	593	1.2 (1.8)	2.9 (2.4)	13	39	3.7	15

NRS = numeric rating scale score ranging from 0 to 10.

Table 2 Median numeric rating scale (NRS) pain score at rest and active for selected surgical procedures

	Rest NRS (out of 10)			Active NRS (out of 10)		
Surgical Procedure	Median	Mean	SD	Median	Mean	SD
Abdominal aortic aneurysm (N = 46)	0	0.8	1.7	2	2.1	2.4
Hemicolectomy (N = 42)	0	1.2	1.8	2	2.7	2.7
Thoracotomy (N = 87)	0	1.4	2.3	2	2.6	2.7
Prostatectomy (N = 47)	1	1.4	1.7	3	3.7	2.1
Hysterectomy (N = 245)	1	1.6	1.9	3	3.6	2.6
Total hip (N = 217)	1	1.7	1.9	4	4.1	2.4
Total knee (N = 204)	2	2.0	2.1	4	4.3	2.5
Rib fracture (N = 12)	2	2.2	2.2	4	4.6	2.8

majority (77%) were admitted postoperatively. The mean length of stay on the APMS was 2.3 days (SD = 2.3), with 25% of patients remaining on the service for at least 3 days. There were a total of 8,726 APMS visits to 2,528 patients during the 1-year period. Table 1 describes the number of elective postsurgical patients on the service by postoperative day as well as their average rest and active pain scores by postoperative day. Sixty-one percent of patients reported an NRS score greater than 3 (out of 10) when active, while 35% reported scores greater than 5 when active. Resting and active pain scores were highest for patients who underwent hip or knee surgery, or suffered fractured ribs (Table 2). Mean pain scores ranged from 0.8 at rest for patients who underwent abdominal aortic aneurysm surgery to 4.6 with activity for patients with fractured ribs.

Over half of the patients received patient-controlled intravenous analgesia while 20% received an epidural as the primary analgesic modality (Table 3). Seventy percent of patients received coanalgesia along with the primary modality. Morphine was the primary analgesic administered via patient-controlled intravenous analgesia as well hydromorphone, fentanyl and in very rare occasions meperidine patient-controlled analgesia was prescribed.

More than one-quarter of patients experienced at least one side effect while on the APMS. The most common side effect reported during all postoperative visits was nausea (35%), with the highest incidence of nausea reported on postoperative day two (Figure 2). Intractable nausea/vomiting as a notable event (an unusual event deemed important for continuous quality improvement) was reported

Table 3 Pain modalities provided by the APMS to all APMS patients (postoperative and consults)

Type of Pain Modality	Number of Patients (N = 2,564)	Percent of Patients
Coanalgesia – acetaminophen ± ketaprofen	1,783	70
Patient controlled intravenous analgesia	1,658	65
Epidural	507	20
Spinal	420	16
Peripheral block	234	9.1
Epidural – patient controlled	109	4.3
Brachial plexus block – single shot	40	1.6
Trunk block	27	1.1

APMS, Acute Pain Management Service.

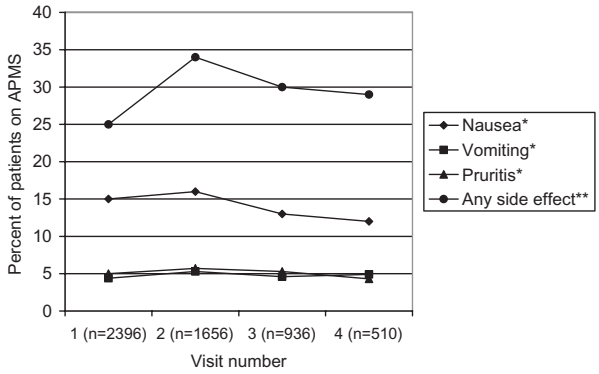

Figure 2 Number of patients reporting side effects stratified by the number of times a patient was "visited" by the Acute Pain Management Service (APMS). *Only side effects requiring treatment; **Any reported side effect whether it required treatment or not.

on 20 patient visits. Table 4 presents the number of unusual or notable events reported during the 1 year of data collection.

Clinical Interpretation

The results of this descriptive analysis of the APMS over the past year are consistent with the anecdotal evidence about patient outcomes on the APMS. We are able to provide a comprehensive description of the APMS population and to evaluate some key patient outcomes related to pain management. APMS clinicians are able to support experiential knowledge with real-time data. For example, active pain scores for patients following knee arthroplasty (N = 204) are above acceptable levels for facilitating physiotherapy (mean = 4.3/10). As the data accumulate in the APMS database, we will conduct more in-depth analysis of pain outcomes associated with specific surgical procedures, pain modalities, medications, side effects, and notable events. In addition to the development of care maps and the facilitation of knowledge transfer, our interdisciplinary pain research group is exploring predictors of chronic postsurgical pain.

Table 4 Number of "notable events" or unusual events reported by the APMS during a one year period

Notable Event	Total No. of Patients
Intractable pain	51
Epidural or spinal catheter issues	36
Intractable nausea/vomiting	20
Respiratory depression	10
Neurologic symptoms	9
Hypotension	8
Naloxone	8
Pump issues	6
Intractable Pruritus	3
Post dural puncture headache	2
Medication error	2

APMS, Acute Pain Management Service.

Future Directions

Currently electronic assessments are only documented by the APMS; the data are limited to patients admitted to the APMS and assessments conducted by the APMS. Future enhancements could include the collection of electronic data by the frontline staff and possibly even the patient. We have conducted studies that indicate that patients may be willing and able to enter patient data into electronic charts using touch-screen technology [17,18]. A detailed review of corporate and clinical barriers to adoption and possible strategies to address these barriers is underway. Early clinical observations suggest a reduction in renal insufficiency from indiscriminant use of nonsteroidal anti-inflammatory drugs, and decreased likelihood of prescribing low molecular weight heparin with indwelling epidural catheters. However, further studies have yet to be conducted to evaluate the impact of electronic monitoring on the outcomes of care on an APMS. Our studies indicate that documentation on a portable computer is more comprehensive than documentation on paper [3,10]. Future studies will compare outcomes between patient care units that document acute pain assessments on paper versus computer. Medication errors and missed or delayed response to abnormal test results will also be evaluated in future studies.

Conclusion

The impetus for the development of the APMS electronic system in our institution was twofold: to record APMS clinical activity and to improve the quality of the evidence for the improvement of patient care. As a result of our experience over the past 7 years, we identified some key priorities in the development and implementation of an acute pain management tool, which we believe are applicable to the adoption and sustainability of any health care electronic tools:

- The user must always drive the development and maintenance of clinical software.
- There must be a strong link between the monitoring of clinical and research outcomes to ensure the usability and integrity of the information collected.

- Ready access to the data offers significant benefit for quality improvement at the time of care.
- Ongoing data collection in an acute care setting contributes unique and valuable information to outcomes monitoring and Phase IV drug trials.
- Creative solutions to process problems are required (e.g., printing electronic assessment to provide transition from paper to electronic records).
- Executive sponsorship and alignment of projects with the mission, vision, values, and strategic priorities of the organization is essential.

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