The Integration of Hospital Information Systems, Peri-operative Information Systems, and Operative Equipment into a Single Information Display

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Summary: The integration of disparate information systems in the operative environment allows access to information that is typically unseen or unused. Through a collaborative effort, a variety of information systems and surgical equipment have been integrated. We have developed an improved context-sensitive information display and improved access to information in order to improve workflow, patient safety and visualization of previously unattainable information. A decision support component is being developed.

Introduction: Just-in-time access to information is essential in the operative environment yet much information flow occurs from disparate systems going unrecorded, unseen and thus unutilized. An integrative approach to surgical information management would increase access to information, decrease duplicate data, and potentially improve operative and peri-operative safety. With currently available high speed desktop computers, bedside integration of this information is now possible. A collaborative project by Massachusetts General Hospital and LiveData, Inc. is integrating and displaying information from a variety of disparate systems to improve situational awareness, capture and consumption of medical data in the Operating Room of the Future (ORF) at Massachusetts General Hospital.

Methods: All operating room digital data sources including anesthesia and surgical devices as well as hospital information systems were catalogued. A block diagram representing the integration of the devices was developed (figure 1). Key data elements from each integrated device were identified for redisplay.

Results: Software interfaces were developed for each integrated device. The integration system was developed to run on a standard desktop PC with video output to a 42 inch LCD display. Integrated devices include: physiologic monitors, level-of-consciousness monitoring, syringe micro-infusion pump, surgical insufflator, and multiple hospital information systems including computerized physician order entry, allergy database, nursing perioperative record and patient / physician location tracking systems.

Discussion: The integration of these previously isolated information sources creates new opportunities for decision support and augmented vigilance. Allergy information from the hospital information system may inform the team that the patient specific drug allergies or is latex allergic. The integrated data display may alert the team of an impending adverse event before an infusion pump administers a potentially harmful drug. Integrated information from the physiologic monitor and laparoscopic insufflator can inform the team of bradycardia and impending asystole. The location tracking system automatically checks the accuracy of patient identity and updates the team on changes in OR personnel. Pertinent orders, labs, medications and medical problems from the hospital information system, computerized physician order entry system and anesthesia information system can be continuously displayed throughout the operative period to increase access to knowledge and decrease uninformed or delayed decisions.

Conclusions: Disparate information systems in the perioperative environment have been integrated via a standard desktop PC with video output to a 42-inch LCD display. Augmented vigilance systems are currently under development.

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Introduction: Just-in-time access to information is essential in the operative environment. All OR personnel depend on ready access to complete and accurate patient and system status data, but they each must individually integrate the data from disparate sources to effectively make safe decisions. This is inefficient, diverts caregivers from patient care, and potentially degrades safety. Additionally, individual care givers have access to differing information potentially leading to variable conclusions and decisions based on integration of less than complete data. A collaborative effort through Massachusetts General Hospital (Boston, MA) with software developers (LiveData, Inc., Cambridge, MA) and human factors designers (Aptima, Inc., Woburn, MA) has developed a system to integrate all operative room digital data into a single, high definition, large format display visible from anywhere in the operating room (OR). The system runs on a standard desktop PC with output to a 42-inch LCD display visible from any vantage point in the operating room thus providing full integrated data to each member of the perioperative team.

Methods: All OR digital data sources were catalogued, including anesthesia and surgical devices such as the laparoscopic surgical insufflator, anesthesia physiologic monitors, breathing circuit analyzers, level-of-consciousness monitors, the anesthesia machine, ventilator, and medication infusion pumps, as well as OR / hospital information systems including the computerized provider order entry system, anesthesia information system, surgical video system, nursing perioperative record and real-time patient, staff and equipment location tracking (Radianse, Lawrence, MA). Key data elements from each device and system were identified for redisplay on the integrated system to create a single-display snapshot of the patient. A block diagram representing the integration of the devices was developed (figure 1) prior to actual development of the computerized integration system. Augmented vigilance and decision support specifications are being developed.

Figure 1

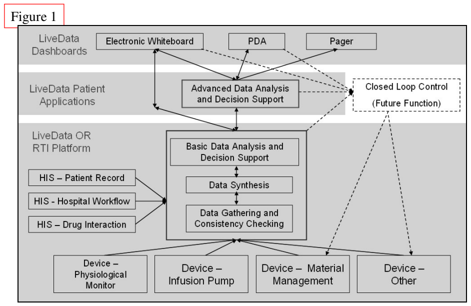

Figure 1 represents a block diagram with information sources being integrated. These include a wide variety of surgical instruments, information systems and ancillary computer systems for workflow support and tracking. Surgical instruments include the laparoscopic surgical insufflator, physiologic monitors, breathing circuit analyzers, level-of-consciousness monitors, the anesthesia machine, and medication infusion pumps. Information systems include the hospital information system (HIS), computerized provider order entry system, anesthesia information management system and nursing perioperative record. Ancillary systems include a sophisticated location tracking system.

Results: Software interfaces were written to obtain key data from most of the devices and information systems catalogued; the remainder are in progress. The system runs on a standard desktop PC in the OR with a consumer video card and 42" LCD display. We were able to obtain and interpret digital output from a variety of physiologic monitors including the BIS monitor (Aspect Medical Systems), and a surgical insufflator (Storz, Galena, CA). Trending of physiologic, gas and endosurgical device data is provided. Integration of the anesthesia information system (Saturn, Drager, Telford, PA), the nursing perioperatigve record, our OR Dynamic Scheduling system, and enterprise-wide patient allergy database and real-time location systems was achieved via HL-7 and XML interfaces. The high-level block architecture of the system and selected integrated resources is shown in figure 1. All data are archived. Surgical field and / or laparoscopic video images are shown on a separate display (visible in figure 3).

Dynamic elements of the integrated display advance automatically, triggered by the logging of case milestones in the NPR. This provides context specific information without requiring OR personnel to interact with the system. A progress log of key intraoperative events appears on the right, while a timeline of the day's cases will appear across the bottom of the display.

Figure 2

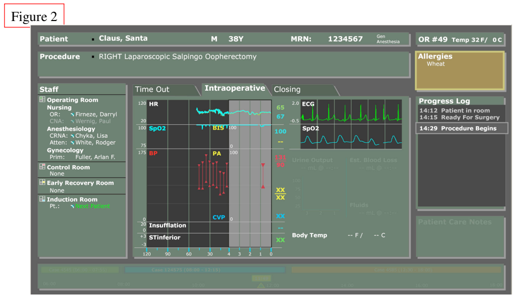

Figure 2 demonstrates a screen shot of the information display. High level patient demographic (sanitized for HIPAA compliance in this actual image) and procedure information along the top lines help maintain orientation through staff turnover while also providing persistent display of time-out oriented information. Allergies are clearly displayed in the upper right corner throughout the case for all members of the perioperative team to visualize. Staffing and patient location information is detailed in the left hand column of the display. This information is automatically populated via Radianse tracking data. As members of the perioperative team come and go from the operating room, the list is automatically updated in real time. This system also helps verify patient identity. Physiologic data is presented in an integrated trend area to provide a single view of all physiologic parameters applicable to the patient and for which data are currently being collected. This view allows for easy correlation and integration without necessitating analysis of multiple monitors and displays. These data may also be used in workflow support to provide advanced scheduling and resource management. The whole OR timeline along the bottom of the screen provides a snapshot of the previous, current and upcoming cases along with the current position in the day. Such a timeline may be expanded to include PACU and patient arrival information to provide a more global awareness of patient and case status.

Discussion: The integration of these previously isolated information sources paves the way for new opportunities in the development of decision support and augmented vigilance systems. Allergy information from the hospital information system may inform the team that the patient has specific drug allergies or is latex allergic. The integrated data display currently alerts the entire team to real time physiologic data, personnel in the room and critical events related to the progress of the case.

With the development of decision support and augmented vigilance systems, smart alarms can be integrated from this data to alert the perioperative team of impending physiologic events such as asystole following progressive bradycardia or insufflation of the peritoneal cavity in addition to helping communication between team members currently in the room by providing the names of the currently present staff.

The location tracking system can automatically check the accuracy of patient identity and update the team on changes in OR personnel. Pertinent orders, labs, medications and medical problems from the hospital information system, computerized physician order entry system and anesthesia information system can be continuously displayed throughout the operative period to increase access to knowledge and decrease uninformed or delayed decisions.

Conclusions: We have achieved whole-OR, single display integration of all key patient information needed to obtain an instant snapshot of the patient's status. This work was deliberately done in a vendor-agnostic framework to allow the fullest possible integration of the installed base of legacy systems whose useful lifespan is long. Proprietary solutions are less desirable because they do not easily integrate data from exogenous sources.

This system provides improved contextual real-time information awareness, real-time access to readiness information, and improved workflow and patient identiy management. Trending of devices that impact and monitor patient status (i.e.,[insufflator and physiologic monitor] or [gas/infusion devices and level-of-consciousness monitor]) is gathered together on a single user interface. This system provides visual integration that facilitates a more holistic view of the patient-procedure-anesthetic interactions. In the future it will serve as a platform for augmented vigilance and machine-assisted decision support in the OR.

Figure 3

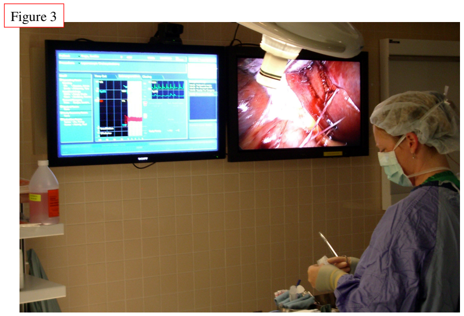

Figure 3 is a real-time snapshot of the operating room with the integrated display side by side with live video of the surgical procedure