Information Technologies and Patient Safety

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The last decade has seen a proliferation of advances in the area of patient safety. At the core of these advances has been the rapid expansion of health information technology (HIT). HIT is defined as the use of electronic and personal health records, automated decision support systems, alerts and reminders, and various technologies for clinical, financial, and administrative purposes.\textsuperscript{1,2} HIT has broad applications as an effective tool that can enhance the safety and quality outcomes of the patient across the health care continuum.\textsuperscript{3–5}

In 2009, the Health Information Technology for Economic and Clinical Health (HITECH) Act was passed as part of the American Recovery and Reinvestment Act. The Act provided stimulus funding for hospitals and clinicians to implement HIT strategies to improve the quality and safety of patient care.\textsuperscript{6} This federally subsidized program authorized the allocation of $27 billion to provide financial incentives for hospitals and clinical practices to adopt and use electronic health information. In addition, HITECH requires the “meaningful use” of electronic health records (EHRs) by eligible providers and hospitals. The core objectives of meaningful use are to improve the delivery of health care. Monetary incentive payments and/or penalties of withholding reimbursement by the Centers for Medicare and Medicaid Services (CMS) will be tied to compliance with the core objectives of meaningful use.\textsuperscript{7} The overarching goal, within the provisions of HITECH, is to spur technological advances to improve the health of Americans and the performance of the health care system.\textsuperscript{8} The barriers and challenges to universal adoption of an integrated HIT network by health care systems are ever present,\textsuperscript{9} but 92\% of evidence-based systematic reviews favorably

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support its continued development. Increasing acceptance and use of HIT will play a critical role in the enhancement of safety and the quality of care for the surgical patient.

Within the perioperative process, patients are at risk for adverse events from diagnostic and therapeutic errors. The unintended consequence of these errors is the potential harm to the surgical patient. Error prevention and detection strategies using HIT have been advocated to protect patients. A seminal paper by Bates and Gawande described HIT strategies including (1) tools to improve communication, (2) to make knowledge more accessible, (3) to require key pieces of patient information to be available, (4) to perform checks in real time, (5) to assist with monitoring, and (6) to provide support for clinical decision making. Specific applications of these strategies to prevent medication errors have been shown through computerized physician order entry (CPOE), bar code scanning technology, automated tools for safe patient handoffs, surgeon preference cards, and supply inventories. Built-in prompts with alerts and reminders of pending laboratory or radiology results have been shown to facilitate communication for providers.

The operating room provides many opportunities for improvements in patient safety. Innovations in HIT such as bar code technology and radiofrequency identification (RFID) have been applied to creating tracking systems. These technologies have shown promise in decreasing the rate of retained sponges in surgical patients. Computerization of perioperative records has facilitated the capture of real-time data to improve documentation and communication by surgeons, anesthesiologists, and operating room personnel. An automated operating room computer system designed and based on informatics can provide important data on processes of care and surgical outcomes.

This article describes the current and future framework of HIT as it applies to improvements in safety and quality for the surgical patient through the perioperative process. Specific areas of focus include the use of EHRs to enhance provider communication, intraoperative bar code and RFID technologies for surgical error prevention, informatics to improve operating room situational awareness and team performance, and standardized automated data collection to analyze outcomes.

IMPLEMENTATION OF EHRs FOR SURGICAL CARE

The spectrum of surgical care involves many phases of patient-provider encounters generating a wealth of information. Optimizing the flow of information about the surgical patient within the preoperative, intraoperative, perioperative, and outpatient settings can be challenging. Essential to the successful coordination of care to overcome these challenges are the advances in computerized technology. These advances have provided opportunities to enhance the communication of patient information. The cornerstone of HIT has been the emergence of EHRs providing legible, digitized patient data from various sources within a central, accessible, Web-based repository. Information available within the surgical patient’s EHR includes progress notes, operative dictations, CPOE, laboratory and radiological tests, and e-prescribing capabilities. Accessible patient data within an electronic network shared by surgeons, anesthesiologists, subspecialists, nurses, referring providers, and primary care physicians is paramount to the success of the surgical outcome. Whether the patient is a young and healthy individual undergoing a laparoscopic inguinal hernia repair or a complicated, morbidly obese patient requiring an extensive preoperative workup for weight loss surgery, the EHR has the advantage of organizing and providing key information for all providers.
The referral process is an important point of care that can have serious implications for patient outcomes. The communication of patient information from the referring provider to the specialist is essential to a timely and thorough consultation. In addition, the consultative plan from the surgical specialist should be conveyed back to the referring provider to facilitate the transition of care. Studies have shown that an inherent dissatisfaction among primary care providers and specialists exists within the referral process. The reasons for this dissatisfaction include unclear explanation of the patient’s active problem, delayed or missing referral reports, and failure by the specialist to respond to the referring provider. The EHR provides a clear synopsis of the patient’s problems, facilitates appointment scheduling, and tracks consultative visits. These features have successfully improved communication between providers.

A new generation of computerized health information is a critical adjunct to conveying patient data from the surgeon to the operative team. Through electronic portals, patient information can be transmitted not only to the anesthesiologist but also to the preoperative processing center in a timely fashion to prepare for an upcoming procedure. Key information regarding patient comorbidities, allergies, and active medication use can be electronically communicated to all team members. This procedure allows ample time for the team to review the patient’s current health history in collaboration to facilitate the plan of care. A delineated plan of care through a preprocedure briefing, which is understood by the entire team, minimizes the risk of safety-compromising events during the operative procedure. Furthermore, a perioperative EHR has been shown to improve throughput and increase efficiency by reducing late case start times and decreasing operating room turnover time.

In the postoperative period, the EHR allows surgeons to update the patient’s chart in real time. Important pieces of information such as the type of procedure performed, medication reconciliation, attention to wounds, and dressings can be shared electronically with covering surgeons, the patient’s primary caregiver, and nursing and ancillary personnel to prevent adverse outcomes and readmissions. Thirty-day hospital readmissions rates have been reported to occur in 5% to 29% of all medical-surgical inpatient discharges. Inadequate transfer of information regarding patient hospitalizations to transitional care teams has been shown to be an attributable factor to hospital readmissions. Roy and colleagues determined that the results of 41% of inpatient tests were received after discharge. Two-thirds of physicians were unaware of these results, 50% of which required some form of provider intervention. Automated prompts within the EHR alert all providers in the transition of care, facilitating the communication of impending tests or laboratory results that, if missed, could lead to an adverse outcome.

Patients who take an active role in their health care are more likely to experience better outcomes. EHRs have the potential to improve communication between the surgeon and patient. Access to secure portals, interfaced with the EHR system, allows patients, as consumers, to view their medical information. This transformative technology empowers patients to view their own personal EHR to share in the decision-making process. Preliminary studies in diabetes management have shown improved outcomes with patient engagement in Web-based portals integrated through EHRs. In accordance with stage 1 meaningful use requirements, patients are required to receive a clinical summary of their physician visit within 3 business days. On physician completion of the patient encounter, a clinical summary is automatically generated and delivered for the patient’s own personal health record. Most importantly, patients’ access to their EHR helps to create trust in the surgeon and fosters informed decision making about the plan of care.
Despite the benefits of EHRs, several limitations and barriers exist to wide-scale adoption. In 2009, only 11.9% of hospitals in the United States had adopted a basic or comprehensive EHR system. Cited barriers include lack of capital for EHR purchase, physician resistance, and inadequacy of hospital staff expertise for maintenance and troubleshooting. For all patients to receive the benefits of EHR, federal policy makers need to address these barriers through improved education, incentives, and technical support.

BAR CODE TECHNOLOGY AND RFID

With the rapid increase in surgical technology, surgeons continue to face challenges for implementation of safe practices for their patients. In the 1999 publication *To Err is Human: Building a Safer Health System* by the Institute of Medicine, it was shown that surgical errors were second only to medication errors as the most frequent cause of error-related deaths. Despite protocols to reduce the potential for error, specifically retained surgical items (RSIs), surgeons as a whole have achieved only limited success. The environment in the operating room is complex with rapid acceleration of newly adapted technology into the surgical field. The operating room staff is faced with an increasing amount of documentation and manual verification in an attempt to decrease RSIs. This requirement can have a measurable impact on operating room efficiency. However, investigation of new technologies to increase efficiency and improve patient safety is now becoming available for implementation.

The occurrence of RSIs continues to be a significant patient safety issue, with approximately 1 occurrence in every 1500 abdominal operations. Every body cavity has been involved in a documented RSI case, but the abdominal cavity continues to be the most common location (46%–55%). Negative outcomes associated with RSI include reoperation, infection, prolonged hospital stays, fistulas, bowel obstruction, and death. In addition, these adverse events erode patient confidence, as well as hospital and practitioner morale. From a financial standpoint, these events are prone to litigation, at times requiring significant payouts to the patient or family, as well as nonreimbursement from the Centers for Medicare and Medicaid Services.

The current standard for all operating centers in the United States requires at least 1 preoperative manual count performed by the surgical technologist and the circulating nurse and at least 1 postoperative count. Many institutions have increased the number of manual counts to include all instruments as well as sponges in an effort to reduce RSIs. As much as 14% of the operating time is spent conducting manual counts. Despite these efforts, studies at large-volume centers have found manual counts to be only 77% accurate. A concern is that some studies have shown that 88% of RSI occurrences were documented to have correct instrument and sponge counts. In an incorrect sponge or instrument count, the recommended practice is to obtain a plain radiograph of the suspected body region. However, even with intraoperative radiographs there has been a failure to detect as many as 33% of RSIs. This highlights that current methods alone are inadequate in the prevention of RSI.

Bar coding and RFID are promising technologies to prevent RSI while enhancing the safety of the surgical patient. Bar coding is ubiquitous in people’s daily lives. Bar code technology has become integral in tracking inventory and item identification in nearly every retail point-of-sale system in the United States. Bar coding has also become a popular method for patient identification and medication verification systems in hospitals worldwide. The use of bar coded surgical sponges has shown improvements in counting discrepancies compared with traditional counting methods, with a decrease of retained sponges from 12 to 1.7 episodes per 100,000 operations.
RFID is another model currently being evaluated to reduce RSI. This technology, developed in the 1940s, was used by the British military in World War II to identify their aircraft as friendly to anti-aircraft batteries. An RFID model has 2 components: a computerized chip containing information and an antenna to receive and transmit information. Placement of implantable chips within surgical sponges has been described for use as part of investigative RFID technology during operative procedures. This technology has shown higher sensitivity and specificity compared with surgical counts combined with intraoperative radiographs for identification of retained sponges.

Proprietary sponge accounting and detection systems using bar coding and RFID scanning technology are widely available. These sponge scanning technologies have enormous patient safety implications. In particular, these systems can be used routinely for patients undergoing reoperations after damage control surgery, obesity surgery, and in prolonged operative cases. Moreover, studies have shown that these technologies have empowered nurses to be more confident about speaking up when a sponge count discrepancy exists. The promise of these scanning technologies is encouraging; however, to truly protect the patient from RSI, these technologies must be part of a larger strategy that promotes teamwork and includes the collaboration of the entire surgical team.

Additional uses of RFID technology could potentially be incorporated into real-time monitoring of surgical movements and identification of instruments. Through RFID tagging, the location and usage of instrumentation during a procedure could trigger an alert to the surgical team to prepare for changes in the operative plan. For example, uncontrolled, excessive bleeding during laparoscopy would alert the team to the potential for conversion to an open procedure. Prompt notification to the team leaders at the operating room communication desk of a change in plan could generate schedule changes and staff reassignments to maintain optimal workflow. RFID tags in disposable items would allow for continuous monitoring of the operating room inventories, leading to automated orders for purchasing and restocking of supplies.

INTRAOPERATIVE MONITORING AND PATIENT SAFETY

The operating room is a complex environment where critical issues can arise affecting patient safety. Understanding and tracking these issues through computerized intraoperative data systems can help mitigate risk to the patient. Systems are being developed to create a smart operating room that collects data in real time. Automated smart systems would incorporate software to assist in the coordination and completion of not only routine tasks but also those associated with patient safety. For example, the number of circulating nurse room exits is correlated with an increase in patient morbidity. This data collection system would be able to confirm the necessary equipment that is available for the intended procedure, thereby decreasing exits and improving patient safety. Verification of blood products and medication availability can be referenced in real time against a patient’s blood type and allergy profile for compatibility.

Communication and coordination are particularly crucial in dynamic environments such as the operating room. One of the largest contributors to errors in surgery has been the lack of communication within the surgical team. Situational awareness is the ability of a team member to identify, process, comprehend, and communicate the crucial elements of information regarding the environment. Variations in the
situational awareness of the health care team highlight potential problems related to the specifics of the patient or procedure. This problem is exacerbated by the nature of the operating room in the form of shift changes, breaks, and circulating nurse exits if members of the surgical team are present for only segmented portions of the case. Communication with members of the operating room team with real-time, detailed patient and environmental information facilitates increased efficiency and improved patient safety.\textsuperscript{50}

To enhance situational awareness, a black box recorder, similar to those used in the aviation industry, can be used to assess individual and/or team events for quality improvement. Technology like this is needed to collect the complex data to identify and understand the human behaviors that occur in the operating room and their relationship to patient safety events.\textsuperscript{50}

**AUTOMATED DATA COLLECTION**

A highly visible and important issue facing the health care industry is the quality of care provided to patients. To that end, many stakeholders are investing many resources in efforts to collect, analyze, and measure outcomes to improve patient care. Many health care systems use electronic clinical databases to document the care received by patients. Several data collection systems capture information from the patient’s medical record to create a platform for outcome measurement and improvement. Data collection systems currently in use include the National Trauma Data Bank, the Society of Thoracic Surgeons (STS) National Database, Cancer Registries, and the American College of Surgeons’ National Surgical Quality Program (ACS NSQIP). The preoperative, intraoperative, and postoperative variables collected are based on standardized definitions. These data elements would automatically populate the registry and be available for research. This technology will improve data quality by minimizing the risk of keystroke error during the manual entry of information from medical charts. Automation will also allow the quality team to focus on performance initiatives.

The computerization of data to the registries will provide the seamless transfer of information. Reports generated through automated metrics will guide surgeons, administrators, and operating room teams by supporting clinical decision-making strategies through best practices and evidence-based guidelines.\textsuperscript{1} Highly reliable, automated registries are essential to drive performance improvement. As health care reform evolves, regulatory pressures will be ever present and reimbursement will be tied to the accurate measurement of outcomes.

**SUMMARY**

In the last decade, patient safety has evolved in the discipline of surgery. HIT will play an important role in advancing safety and quality of care for the surgical patient. The electronic health record provides an up-to-date snapshot of important patient information that should be accessible to all health care providers to improve communication. Surgical errors such as retained items can be mitigated through technologies such as bar coding and RFID. Smart operating rooms have the advantage of improving situational awareness to enhance team performance. Automated data registries built with platforms to abstract, analyze, and report back patient outcomes are imperative to drive surgical quality improvement. Surgeons as leaders need to adapt to these advances in HIT. Implementation of health information systems will have a profound effect on optimizing safety and the quality of care provided to patients.
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