Bar Code and Radio-Frequency Technologies Can Increase Safety and Efficiency of Blood Transfusions

S. Gerald Sandler, MD,1 Albert Langeberg, MT,1 Kimberly Carty, RN,2 Laurie J. Dohnalek, RN, MBA, CNA2

(1Department of Laboratory Medicine and 2Nursing Services, MedStar-Georgetown University Hospital, Washington, DC)

Abstract

Bar-coded labels on wristbands, blood sample tubes, and blood components can facilitate matching the “right” blood unit and the “right” patient. Nurses preferred to verify their patient-blood unit identification matches by scanning bar code labels rather than seeking out a second nurse for a conventional visual “double check” verification. Occasional scans of bar-coded wristbands failed because of crinkles, food spills, and blurring due to bathing. Also, inadvertently scanning the wrong bar code on a blood component signaled the program that a mismatch was occurring and “shut down” the system, according to the requirements of our software program. Radio-frequency identification (RFID) labels on wristbands and blood components were easier to scan, but bar-coded labels may be adequate for personal identification cards and labels on blood sample tubes for budget-conscious transfusion safety systems. We envision significant advantages to combining transfusion safety and medication dispensing systems, using common hardware and complementary software programs.

As hospital transfusion services seek ways to meet expectations for error-free blood transfusions, 2 electronic technologies emerge as potential solutions. First, bar code systems are now available that have been designed to ensure positive identification of patients, their blood samples for compatibility testing, and their blood components intended for transfusion. Second, radio-frequency identification (RFID) transponders (“chips” or “tags”) are also available as alternatives to bar codes in selected clinical situations. In the following report, based on 10 years’ of studies at Georgetown University Hospital, we describe our experience with bar code- and RFID-enabled systems and propose ways that these technologies may be applied to improve the safety and efficiency of blood transfusions.

Prototype Electronic Transfusion Safety Systems

Our first experience using electronic systems to improve transfusion safety at Georgetown University Hospital began in 1972 when we obtained a research grant from the National Institutes of Health to develop a prototype electronic system to improve the identification of patients and their intended blood component.1 The system, designed by American Science and Engineering (Cambridge, MA), was based on a punch-card-like technology using encoded 9-digit numbers on thermally-sensitive Mylar labels. We placed bar-coded labels at 3 key locations in the blood transfusion loop: on the patient’s identification wristband, on the patient’s blood sample tube for compatibility testing, and on the blood component intended for transfusion. The system included a human- and machine-readable wristband, a portable device to transfer the wristband’s unique number to a blood sample tube label, a device for the blood bank to transfer the number from the blood sample tube label to blood container tags, and a bedside device to electronically verify that the number on the blood container’s label matched the number on the patient’s wristband’s. While this prototype electronic system was too cumbersome to be marketed commercially, it identified the key locations in the transfusion loop where electronic identification systems could add to the reliability of conventional visual identification and verification methods.

In 1996, Jensen and Crosson described a prototype bar code-enabled identification system for blood transfusions.2 They described a bedside transfusion system for verifying patient and blood unit identification using preprinted materials with a unique bar-coded identification numbers (Hollister, Libertyville, IL). This system verified the identification of patients using a portable hand-held laser scanner (Healthcare-ID, Libertyville, IL) and a personal computer. The scanner read the operator’s identification badge (International Society of Blood Transfusion number 128 bar code symbology), the patient’s wristband number, and the identification numbers on the blood component for transfusion. If identification numbers did not match, the device alerted the operator by an audible signal. While this system was not marketed commercially, it demonstrated how bar code technology could be used to complement visual matching of patients and their intended blood components for transfusion.

Experience Using a Bar Code System on a High-Volume Transfusion Service

We,3,4 and others5-7 soon followed, describing similar bar code-enabled systems that had been developed to verify conventional visual matching of patients, their blood samples and their blood components intended for transfusion. In 1998, we initiated a pilot study of the I-TRAC bar-code system (subsequently, I-TRAC-Plus, Immucor, Norcross, GA) which consisted of a hand-held portable data terminal/scanner (Symbol STP 1500, Symbol Technologies, Holtsville, NY) with a software program (Healthcare-ID) to drive the scanner’s verification process by providing a sequence of cues to the operator.8 In retrospect, it was significant that we evaluated the system on our hospital’s high-volume Outpatient Infusion Service, where each nurse was likely to transfuse one or more blood components daily. The bar code identification process began when a physician ordered a blood transfusion and the patient’s nurse printed a unique bar-coded wristband for the intended recipient. The nurse then
logged in by scanning his/her bar-coded personal identification card (for an electronic operator’s signature), scanned the patient’s wristband using a Symbol STP 1500 scanner, and beamed the data to a portable adhesive label printer (Model P2222, Zebra Technologies, Vernon Hills, IL) to generate a bar-coded label for the blood sample tube (Image 1).9 The blood sample tube and blood transfusion order form were delivered to the blood bank, where the bar-coded label on the blood sample tube was read and the data recorded in the information system (Lifeline, Mediware, Lake Oswego, OR). We tested patients’ bar-coded sample tubes for ABO/Rh and antibody screens using an ABS2000 automated blood typing analyzer (Immucor).10 If an instant-spin crossmatch verified serological compatibility between the recipient and the blood component selected for transfusion, we generated an eye- and bar code-readable crossmatch label, which we affixed to the reverse side of the blood unit container. To initiate the pre-transfusion verification of the “correct unit” and “correct patient” at the bedside, the patient’s nurse compared information on the container’s label and patient’s wristband, item-by-item, by the standard visual method. This visual matching of patient and blood component information served as the identification-of-record as required by AABB Standards (number 5.19.A).11 Instead of a conventional “double check” verification, which is usually conducted by a second nurse, the “double check” was performed using the hand-held data terminal/scanner to compare information contained on the patient’s bar-coded wristband and the blood component’s crossmatch label. Nurses’ evaluations of the system, based on more than 1,000 transfusions, were enthusiastic. As we anticipated, nurses preferred performing the “double check” verification using a personal data terminal/scanner, compared to the inconvenience of locating a second nurse to assist with a visual “double check” verification of patient-blood unit information.

Experience Using a Bar Code System on a Low-Volume Inpatient Nursing Unit

Based on this experience, we initiated a second evaluation, this time on the hospital’s inpatient Hematology/Oncology Service. The pertinent difference between the outpatient and the inpatient nursing units is that nurses on the high-volume outpatient service transfuse patients multiple times daily, whereas nurses on the low-volume inpatient service may not administer a blood transfusion more often than once weekly. This difference proved to be very important. We started this study in 2000. Immucor had discontinued distribution of I-TRAC-Plus. We selected MedPoint-Transfusion (Bridge Medical, Solona Beach, CA), which is a bar code system for transfusion safety that, for the purposes of our study, was essentially identical to I-TRAC-Plus. Together with the manufacturer, we conducted an in-service for all nurses, training them on the proper use of the hardware and software for bar code-enabled identification verifications. Within a few weeks of completing their in-service, several nurses informed us that they were experiencing 2 new problems.12,13 First, many nurses felt that they were not using the system sufficiently often to maintain their proficiency or confidence. While they, also, appreciated the convenience of performing “double check” verifications without having to locate a second nurse, they were concerned that using the hardware and software only once or twice weekly was not adequate for maintaining their proficiency. They preferred to return to conventional visual verifications, including “double check” verifications by a second nurse. After some discussion, there was general consensus that combining the bar code transfusion system with a similar bar code-enabled medication dispensing system would generate the volume of daily transactions needed for nurses to feel confident using the software and hardware. In fact, hospitals in the United States are implementing bar code-enabled medication dispensing systems quicker than transfusion safety systems. We envision the solution to the problem caused by low-volume use of transfusion safety programs will be adding a provision for blood transfusions to medication dispensing programs. Such complementary transfusion safety and medication dispensing systems are now available from several vendors. The second new problem that we encountered on the inpatient service was that bar-coded wristbands were not as readable after a few days’ of inpatient hospitalization compared to a few hours’ or less use in the outpatient service. Bar codes on wristbands were crisp and easily scanned minutes-to-hours after being applied in the outpatient service. However, for inpatients who had been hospitalized for days-to-weeks, bar codes on their wristbands were occasionally difficult to scan, because of food spills, crinkles, and bathing-related smudges during longer hospital stays. While wrinkle- and water-proof bar-coded wristbands are available, the samples we evaluated were relatively rigid, more expensive and less convenient. We decided to use the opportunity presented by this experience to initiate a new study evaluating the potential role of RFID-enabled wristbands for transfusion purposes.

An RFID-Enabled System for Transfusion Safety

To evaluate whether RFID technology offered a potential solution to the problems we were observing with bar-codes, we initiated a study of RFID-encoded wristbands and crossmatch labels.14 Since we had not observed problems with bar-code labels on nurses’ personal identification cards or on bar-coded labels for blood sample tubes, we developed a protocol that was limited to bedside identification “double check” verifications of the “correct patient” and the “correct blood component.” We conducted a 3-way comparison of bedside “double check” verifications for patient-blood unit identification for transfusions by comparing nurses’ experiences using (1) conventional visual method by a second nurse, versus (2) scanning bar-coded labels, versus (3) scanning RFID labels. Patients were identified by wristbands that were eye-readable and contained both a bar code and an embedded RFID transponder (13.56 MHz, 256B) (Smart Band, Precision Dynamics, San Fernando, CA).
We generated blood sample tube labels, as in our prior studies, using information that had been uploaded to a personal data terminal/scanner (modified Pocket PC, Symbol Technologies) from the patient’s wristband. However, for this study, we scanned the data that was encoded in the wristband’s RFID label, rather than the bar-coded label (Image 2). We continued to label patients’ blood sample tubes using bar-coded adhesive labels, since we had not encountered problems with bar codes at this step. We generated bar code and RFID compatibility labels for crossmatched blood components from the digital output of the ABS2000 analyzer (Image 3). The compatibility label merged blood unit- and patient-specific data for bedside verifications. At the bedside, the ‘first’ nurse initiated the 3-way evaluation by performing conventional patient-blood unit identification matching by visually comparing information on the patient’s wristband and on the blood unit’s label (identification-of-record). A second nurse performed a conventional “double check” by visual method and the first nurse repeated the “double check” verification once using a personal data terminal/scanner to read the bar codes and, once again, to scan the RFID labels. The results indicated that the second nurse performed a conventional visual “double check” verification quicker (1-2 minutes) than the first nurse using bar code scans (5-7 minutes) or RFID scans (4-6 minutes). However, all nurses preferred to use their personal hand-held scanners for bar code or RFID “double-check” verifications rather than seek out a second nurse, which could delay transfusions for 30 minutes or more. Also, nurses had the impression that electronic “double checks” were more reliable than visual checks because they, themselves, admitted an occasional lack of focus when stressed by other demands. RFID scans eliminated failures or delays caused by worn or crinkled bar-coded wristbands. We programmed the personal data terminal/scanner to “shut down” if the nurse scanned the wrong bar code when matching the blood component to the intended recipient’s wristband. Our intent was to prevent any “work-around,” since this specific step was critical for eliminating human errors. On several occasions, the system shut down when a nurse inadvertently scanned the “wrong” bar code on the “right” blood component for the “right” patient. The annoyance that this error caused during bar code scans of blood components—some with as many as 6 other bar code labels for various purposes—was eliminated when RFID labels were scanned.

Image 2. An RFID scanner energizes the passive RFID transponder (chip) embedded in the patient’s wristband, which transmits a digital signal containing the patient’s unique identifiers (name, date of birth, hospital number). The scanner has dual capabilities and can also scan bar codes on wristbands, personal identification cards, sample tube labels, or crossmatch labels.

Image 3. An RFID-enabled crossmatch label is affixed to the reverse side of a unit of Red Blood Cells. The RFID tag has been programmed with data identifying the blood unit and the intended recipient. The software program for the PDT requires a scan, also, of the blood center’s bar-code whole blood number label to ensure that the crossmatch label was not placed on the wrong blood container.
We returned the portable data terminal/scanners to cradles to charge their batteries and download their data to the information system (Image 4). This step created electronic records for all transactions that had been facilitated by the data terminal/scanner.

Conclusions

Bar-coded labels on wristbands, blood sample tubes, and blood components can facilitate verification of patient-blood component identifications for blood transfusions. However, in situations where patients are transfused infrequently, nurses may find that infrequent use of the specialized software and hardware reduces their proficiency and confidence. We believe that the solution to this potential problem will be combining the software programs for blood transfusions and medication dispensing. In this mode, software cues for matching patients and intended blood components for transfusion would be similar to cues for matching patients and intended medications. Nurses preferred RFID-enabled “double check” verifications of patient-blood component identification, compared to either visual “double check” verifications by a second nurse or a self-administered bar code scan. While RFID scans required a few minutes more time than a visual verification, they avoided the unpredictable and often longer delays when a second nurse was not readily available to assist. RFID scans were more reliable and quicker when patients had been hospitalized and bar codes on wristbands were compromised by food spills, crinkles, or bathing. RFID scans of crossmatch labels on blood components avoided the risk of a safety-related system “shut down,” if a bar code scan accidentally read one of the other bar codes presently affixed to blood containers.

We believe that bedside identification verification of patients and their blood components can be performed more efficiently using RFID-encoded wristbands and crossmatch labels. Bar codes on patients’ blood sample tubes and personal identification cards are adequate and less costly. A system using a dual bar code and RFID scanner—and combined with the software and hardware of a medication-dispensing program—may be the optimal and practical direction for transfusion services seeking to introduce machine-readable systems for transfusion safety. RFID labels are easier to read on patients’ wristbands and on crossmatch labels on blood units. Both bar code- and RFID-enabled systems can provide electronic records for all steps of the blood transfusion loop.


Image 4. When not in-use, hand-held personal data terminal/scanners were returned to cradles for charging their batteries and downloading their data to information systems.