# Using RFID Technologies to Reduce Blood Transfusion Errors

*At San Raffaele Hospital in Milan, Italy, Intel introduced a pilot program that greatly reduces errors in blood handling. The program uses a wireless infrastructure and radio frequency identification (RFID) technology to automate tracking of blood.*

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## Executive Summary


To reduce blood-handling errors at San Raffaele Hospital in Milan, Italy, Intel, Autentica, and Cisco Systems piloted a program to use wireless-enabled infrastructures and radio frequency identification (RFID) technologies.

Blood transfusion errors have long been a source of concern for hospitals and clinics. The blood-handling process at many healthcare facilities contains a number of manual steps, which can introduce human error. Blood transfusion verification systems also tend to be paper-based and are therefore prone to errors.

In the pilot program, we addressed a critical area for potential errors in the blood transfusion and handling process: the possibility of administering the wrong blood to a patient. This is a serious health care issue, since an incorrect transfusion can trigger adverse reactions up to, and including, death.

The system we introduced uses RFID verification to address the sources of human and systems error in the blood transfusion supply chain. Working with our technology partners, we implemented the pilot at the 1,100-bed San Raffaele Hospital, where over 15,000 blood transfusions are delivered each year.

Benefits of the new system include:

- Better staff mobility and increased efficiency
- Improved data sharing with the hospital's back-end database
- Staff access to blood data at bedside, office, or donation area
- Dramatic reduction in error potential

Most future improvements in health care may not come from better medicine, but from improved systems engineering. As the pilot program described in this paper shows, we can use technology to automate many aspects of health care, addressing real business issues. RFID is a significant technology that, combined with wireless-enabled infrastructures, can make error-prone processes more robust.

# The Business Challenge

The risk of an adverse outcome from an erroneous transfusion is estimated to exceed the risk of acquiring infectious disease such as hepatitis or HIV by transfusion. Erroneous blood administration reportedly occurs in approximately 1 in every 12,000 units; the risk of fatal acute haemolytic transfusion reaction (AHTR) is around 1 in every 600,000 to 800,000 transfusions.

Experts estimate that the actual error rate may be many times higher, since many "near miss" incidents probably go unreported when an error is discovered by pure chance prior to the transfusion. In addition, compound errors generally are reported as a single error, so a mistake in labeling at bedside, combined with a mistake in cross-matching in the blood bank if found at bedside, would generally be reported as a single error.

Any of the following acts, alone or in combination, can cause errors in the blood transfusion process:

- Incorrect labeling, either at bedside or during label printing, due to:
  - Patients with similar or sequential names
  - Inadequate identification of trauma patients or newborn infants
  - Rush situations or "stat" orders
  - Detachment of label during transportation between hospital and blood bank
- Mix-up of samples due to simultaneous handling of specimens from multiple patients
- Mix-up of blood product due to storage in same container of blood destined for multiple infants
- Inadequate cross-matching at the blood bank due to human error

The most common occurrence is the incorrect labeling of samples taken either by blood specialists or other staff. A study by Sharma et al[1] has shown that nearly 80 percent of blood transfusion errors are related to bedside errors or labeling errors, and that blood bank errors account for approximately 13 percent of errors. The primary cause of labeling errors is either confusion or overwriting of the patient's hospital ID number. Within the blood bank, errors are caused by human factors, cross-checking errors, and mistakes by staff who are performing multiple roles simultaneously.

With the large amount of manual checking and paper forms involved, our knowledge of systems theory tells us how frequently these processes are subject to failure.

Bar code solutions have been used in an attempt to reduce error rates. However, a bar-coded wristband is difficult to read if it becomes wet or dirty, or if it is hidden under a sleeping patient, since reading it requires line-of-sight. Identification is even more difficult when a patient is on an emergency room gurney or operating table.

Therefore, a good solution needs to:

- Eliminate labeling and other bedside errors
- Eliminate paper forms and the associated cross-checking they require
- Provide the ability to trace the blood packet throughout the entire cycle
- Offer portability and mobility for tracking and verification

# The Solution

The solution piloted at San Raffaele Hospital dealt with autologous transfusions only. In autologous transfusions, blood is returned to the same donor. In allogeneic transfusions, blood from more than one donor is combined. We chose autologous transfusions over allogeneic transfusions because autologous transfusions are carried out within the confines of the blood transfusion center, which allowed us to fully evaluate the solution before extending it to other hospital departments.

At the core of the system are 13.56 MHz RFID tags. The tags are attached to the patient's wristband and are applied to the blood bag on an RFID card tag.

The hospital's entire blood transfusion center is fitted with a wireless network powered by Cisco Systems' technology. The software, developed by Autentica, runs on stationary PCs, laptop PCs, and personal digital assistants (PDAs).

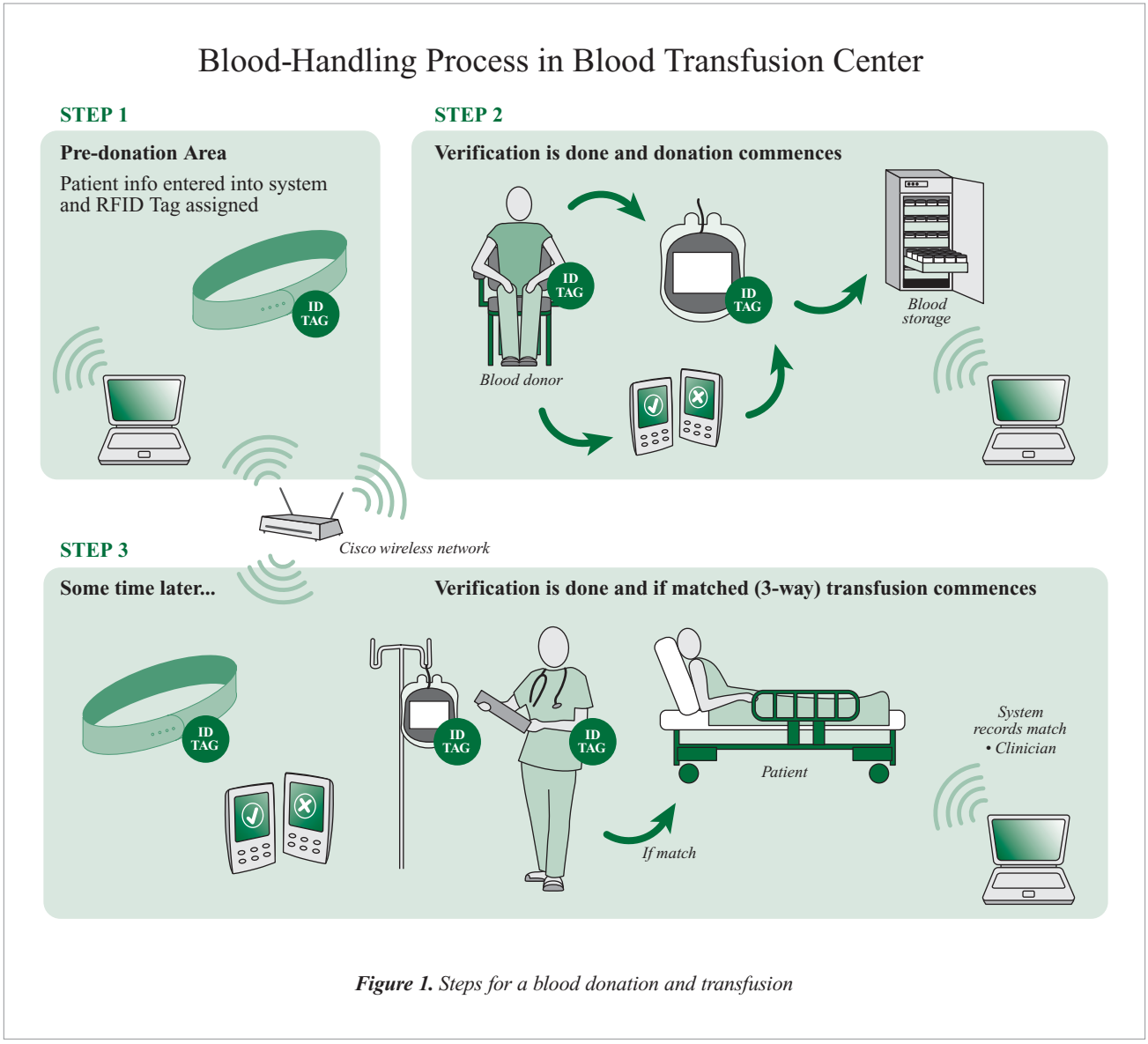


***Figure 1.*** *Steps for a blood donation and transfusion*

## HOW BLOOD IS HANDLED

The hospital's standard operating procedure for blood handling under the pilot project is described here, for both a blood donation and a blood transfusion. Figures 1 and 3 show the blood-handling process.

**Procedure for a Donation**

1. The patient first enters the clinical room, where information such as patient identification number and blood type are recorded in the computer system, and an RFID-enabled wristband with 16 KB of memory is assigned. The wristband contains the patient's personal data along with a picture of the patient, encrypted with Autentica's secure protocol, called IFC.*
2. The patient then enters the blood donation area, which contains the mobile point-of-care (POC) trolley shown in Figure 2. The trolley has a wireless-enabled 1.7 GHz laptop PC using Intel® Centrino™ mobile technology, and a wireless-enabled RFID reader and programmer (PDA). The trolley can be used anywhere within the blood transfusion center. This is the first verification.
3. Before the blood donation, a staff member-a nurse or other clinical staff member-with a portable RFID reader reads the patient's wristband. This information is copied onto the blood bag tag. The staff member uses a PDA to compare the wristband against the blood bag tag, ensuring that they are identical. This is the second verification.
4. Staff members then scan their RFID badges, which contain their personal data, into the system at this point. This completes the "triple verification" process, and the donation can begin.
5. When the donation is complete, a staff member again compares the full blood bag and wristband via PDA scan. The blood is then sent off for storage in the blood bank.

***Figure 2.*** *Mobile POC trolley with Intel® Centrino™ mobile technology laptop PC, plus RFID reader and programmer*

**Procedure for a Transfusion**

1. When the patient's blood is needed at a later time for transfusion, it is brought to the patient's bedside and verified as matching and verified as matching the patient's wristband via a 520 MHz PDA reader based on Intel XScale® technology, shown in Figure 3.

   The information captured contains patient demographics including name and date of birth, an administrative fiscal code, a patient photograph, blood group and type, a donation transaction ID, a patient file ID, and a hospital code. For accuracy, the system requires that the blood group and type each be entered twice.

2. If all information matches, the transfusion can proceed; if not, an error is indicated.

3. The information sent from the bedside to the the blood transfusion center follows all hospital security requirements, using a Cisco Aironet* Access Point wireless antenna installed in the ward.

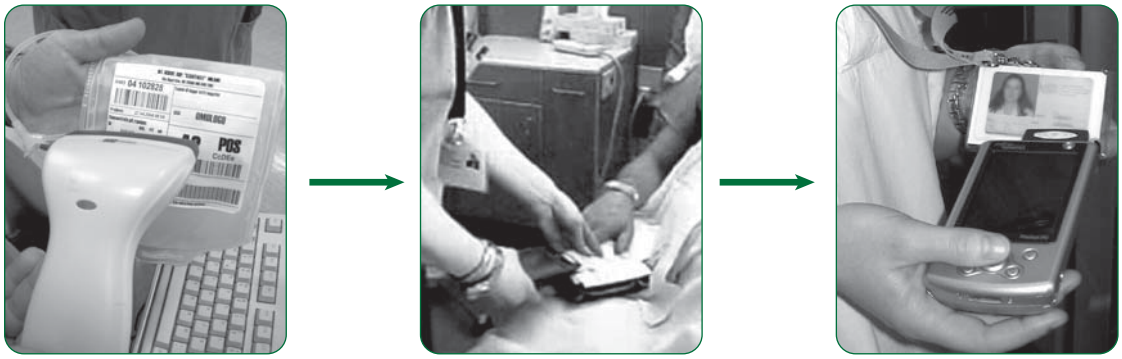

***Figure 3.*** *Transfusion verification procedure showing blood bag scanning, patient wristband scanning, and operator identification entry*

### GENERAL ROI CALCULATIONS

This project's potential return on investment (ROI) is illustrated by a recent Cisco study,[2] which found the following characteristics for wireless LANs:

- Users reported that they are up to 27 percent more productive.
- Since wireless LANs let workers conduct business almost anywhere, employees reported time savings of almost 90 minutes per workday.
- Users who reported improvements in accuracy averaged a 41 percent improvement overall. 70 percent of respondents in healthcare organizations felt the improvement in accuracy was noticeable.

### PATIENT SAFETY ROI

POC through mobile devices has generally been proven to be more efficient and less error-prone than traditional paper-based systems. Therefore, the introduction of electronic medical records (EMRs) and Computerized Physician Order Entry (CPOE), which replaces a hand-written prescription with computer-based form, offers hospitals a definite ROI in patient safety.

Intel previously published a summary of wireless and mobile POC solutions (pocbenefits.pdf, located on the Web at intel.com). A summary of the benefits of these systems includes:

- Improve clinical outcomes by making patient information, diagnostic data, and expert decision support accessible to mobile care providers through lightweight wireless systems. Direct entry of lab and medication orders through mobile POC systems can eliminate the delay and error of manual processes and help accelerate the delivery of treatment benefits.
- Streamline billing processes by capturing billable service and supply charges directly at the place and time of delivery, along with context information for accurate coding.

The previously mentioned publication by Cisco established an average financial return annually per employee of around $14,000 for a mobile workforce.

## Results and Next Steps

After our team completed the pilot program in mid-2004, the hospital moved seamlessly into full production mode within the blood transfusion center. The RFID-based system is now used throughout the department. During the approximate 6-month pilot observation program, no errors were observed in the autologous transfusion process, and ongoing monitoring will be carried out to assess data over a longer time period.

The system ran in standalone mode during the pilot, but has now been fully adopted, and is tied to the hospital's main information system. This links the autologous transfusion system with the patient's main EMR within the hospital, making transfusion information available throughout the main hospital areas.

It's difficult to measure the pilot program's impact because only data estimates were collected prior to the pilot. However, staff members and patients have both provided positive feedback, and staff members have commented that the system has dramatically reduced their fear of introducing errors. It will be several years before we have gathered enough meaningful data to gauge the program's success in solid numbers.

Meanwhile, Intel and our associates on the project have identified the next issues to address:

- Platelet verification and traceability within the department. Platelets are a component of blood; one full platelet unit may contain donations from up to five donors. The ability to track and trace the blood supply from the patient back through the chain including the individual donors would be a major breakthrough. Work on this is currently underway.
- Full allogeneic blood traceability. Due to the nature of the blood bank processes and the numbers of donors involved, this is not a trivial process. However, the ability to fully trace blood ties in with Intel's overall vision of an integrated digital hospital.

## Conclusion

San Raffaele Hospital's pilot program demonstrates that RFID technology can provide a robust solution to the problem of erroneous autologous blood transfusion administration. The program greatly reduces the human factors in blood handling, which greatly reduces the potential for errors.

The blood donor process, from donor through multiple blood banks and hospitals to patient, is being studied by governments and private health care organizations, and will receive great attention in the future. The solution Intel helped introduce at San Raffaele Hospital is part of the future of health care worldwide, which will include a completely transparent blood supply chain.

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## Acronyms

| | |
|---|---|
| **AHTR** | acute haemolytic transfusion reaction |
| **CPOE** | Computerized Physician Order Entry |
| **EMR** | electronic medical record |
| **LAN** | local area network |
| **PDA** | personal digital assistant |
| **POC** | point-of-care |
| **RFID** | radio frequency identification |
| **ROI** | return on investment |

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## AUTENTICA

Founded in December 2001, Autentica develops RFID high technology solutions for the production of safe documents for the identification of persons and objects, and specially to abate the human errors in healthcare.

The total impossibility of documents duplication or data corruption is granted by IFC method, which is based on asymmetric encrypting algorithms.

The Autentica founders put at disposal of this new company their know-how, developed in 40 years of successful business activity in the electronics market; during this period they developed very innovative products, which were the background for the current product offering of the company.

*More information about Autentica is available at* ***www.autentica.it***

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Cisco Systems, Inc. is the worldwide leader in networking for the Internet. Today, networks are an essential part of business, education, government, and home communications, and Cisco Internet Protocol-based (IP) networking solutions are the foundation of these networks. Cisco hardware, software, and service offerings are used to create Internet solutions that allow individuals, companies, and countries to increase productivity, improve customer satisfaction, and strengthen competitive advantage. The Cisco name has become synonymous with the Internet, as well as with the productivity improvements that Internet business solutions provide.

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## SAN RAFFAELE HOSPITAL

The San Raffaele Scientific Research Institute and Hospital of Milan was built in 1970 and has quickly become one of the largest hospitals in Italy. Its workforce consists of about 3,400 employees, houses many laboratories and approximately 1,350 beds. The institute is a place of multidisciplinary culture, combining science in the active support for human life. In 2004 there were over 53,000 hospitalizations. In the same year over 25,000 surgeries were performed and 54,000 emergencies were logged. The institute performed 6 million out-patient services and its laboratories accepted 10,600 referrals.

*More information about San Raffaele Hospital is available at* ***www.sanraffaele.org***

[1] R.R. Sharma, S.Kumar, and S.K. Agnihotri. "Sources of Preventable Errors Related to Transfusion." Vox Sanguinis 2001 81, 37-41.

[2] 2003 Wireless LAN Benefits Study, November 2003, Cisco Systems.



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