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ORIGINAL ARTICLE

Use of an electronic barcode system for patient identification during blood transfusion: 3-year experience in a regional hospital

使用電子標籤系統確定接受輸血病人的身份：一所分區醫院三年的經驗

Objective. To evaluate the use of an electronic barcode system for patient identification during blood transfusion.

Design. Retrospective study.

Setting. Regional hospital, Hong Kong.

Patients. For all patients requiring blood transfusion between May 1999 and April 2002, with the exception of patients in the psychiatric wards and the accident and emergency department, a portable, hand-held scan-and-print electronic device was used to verify and document patients' identity at two critical points of transfusion: blood sampling for the compatibility test and blood administration.

Main outcome measures. Scope of use of the electronic device, cost, effectiveness, staff compliance, problems and solution for improvement.

Results. In the first 3 years of hospital-wide use of the new device, no incidents of blood transfusion to wrong patients, or wrong labelling of blood samples, occurred with 41 000 blood sampling procedures and administration of 27 000 units of blood. Blood sampling took 6 minutes to complete with the use of the electronic device—similar to that taken by the conventional second-checker system. Among hospital staff, the compliance rate of using the new device approached 90%. Battery problems occurred in 12% of episodes of use of the device.

Conclusions. The electronic barcode system was effective in reducing human error related to bedside transfusion procedures. The future goal is to tailor-make a more efficient device with additional functions.

目的：評估使用電子標籤系統確認接受輸血病人身份的效果。

設計：回顧研究。

安排：分區醫院，香港。

患者：1999年5月至2002年4月期間，除精神科和意外及急症部門的病人外，所有接受輸血的病人。在輸血前的兩個關鍵點，即血液相容測試與血液配給前，以一個手提式的掃描打印電子儀器來核實病人的身份，並作紀錄。

主要結果測量：電子儀器的應用範圍、成本、有效程度、醫護人員使用儀器的程度、需要改善的問題以及解決方法。

結果：醫院全面使用這種新的電子儀器的首三年，在41 000次血液抽樣，以及27 000單位血液配給中，沒有出現錯誤輸血，也沒有血液樣本錯貼標籤的情況。使用該電子儀器，血液抽樣需時6分鐘，與習慣上採用人手雙重核對所需的時間差不多。醫護人員使用這個新儀器的比率接近九成。使用儀器時，有12%的時段，電池發生故障。

結論：電子標籤系統能有效減少臨床輸血過程中出現的人為錯誤，研究目標是根據需要設計製造一個更有效、功能更多的儀器。

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Introduction

Advances in molecular science and medical technology have improved the standard of transfusion services in the past two decades, and have made

blood supply much safer than before. Still, incorrect blood transfusion resulting from human error remains a leading cause of transfusion-associated mortality and morbidity.[1-3] In the United Kingdom, according to the Serious Hazards of Transfusion report, such transfusion incidents accounted for 61% (699/1148) of all transfusion-related errors between 1996 and 2001.[4] The report recommended the use of information technology to reduce opportunities for human error during the various stages of the blood transfusion process. One such recommendation was that patients and blood units could be electronically coded and matched. Internationally, several electronic identification systems have been developed, such as the mechanical barrier system,[5] the wristband identification system,[6] the Bloodloc system,[7] and the computerised bedside transfusion system.[8] All are effective in eliminating human error from the transfusion process.

In Hong Kong, the Hospital Transfusion Committee (HTC) of each hospital sets guidelines for transfusion procedures. It also monitors transfusion safety through incident-reporting schemes to identify and analyse transfusion errors. It is widely recognised that even continuous education and training of all levels of staff involved in blood sampling and administration procedures may not totally eliminate human error. In 1999, two regional hospitals in Hong Kong introduced innovative unique patient identifi-

cation (UPI) system to reduce human error related to bedside transfusion procedures. One hospital piloted the use of a specially designed transfusion wristband.[9] The HTC of our hospital designed a barcode system for labelling blood samples and blood units. In this article, we report the 3-year experience of our electronic UPI barcode system.

Methods

System objective

The electronic UPI barcode system at the Pamela Youde Nethersole Eastern Hospital was designed for use in conjunction with the hospital's standard transfusion protocols. It aimed at verifying and documenting transfusion procedures, by an electronic device, at two critical points known to be associated with high incidence of human error: pretransfusion blood sampling for the compatibility test and bedside blood administration (Fig 1). Verification and documentation at these two points were conventionally done visually and manually by one staff with the help of a second person as a checker. The system was not used at the intermediate point—the blood bank—because checking was already part of the existing Laboratory Information System (LIS). By using the electronic UPI barcode system, we aimed to transfer correctly a patient's unique number from his or her wristband onto the blood request form, the blood sample tube, and the blood unit allocated to the patient.
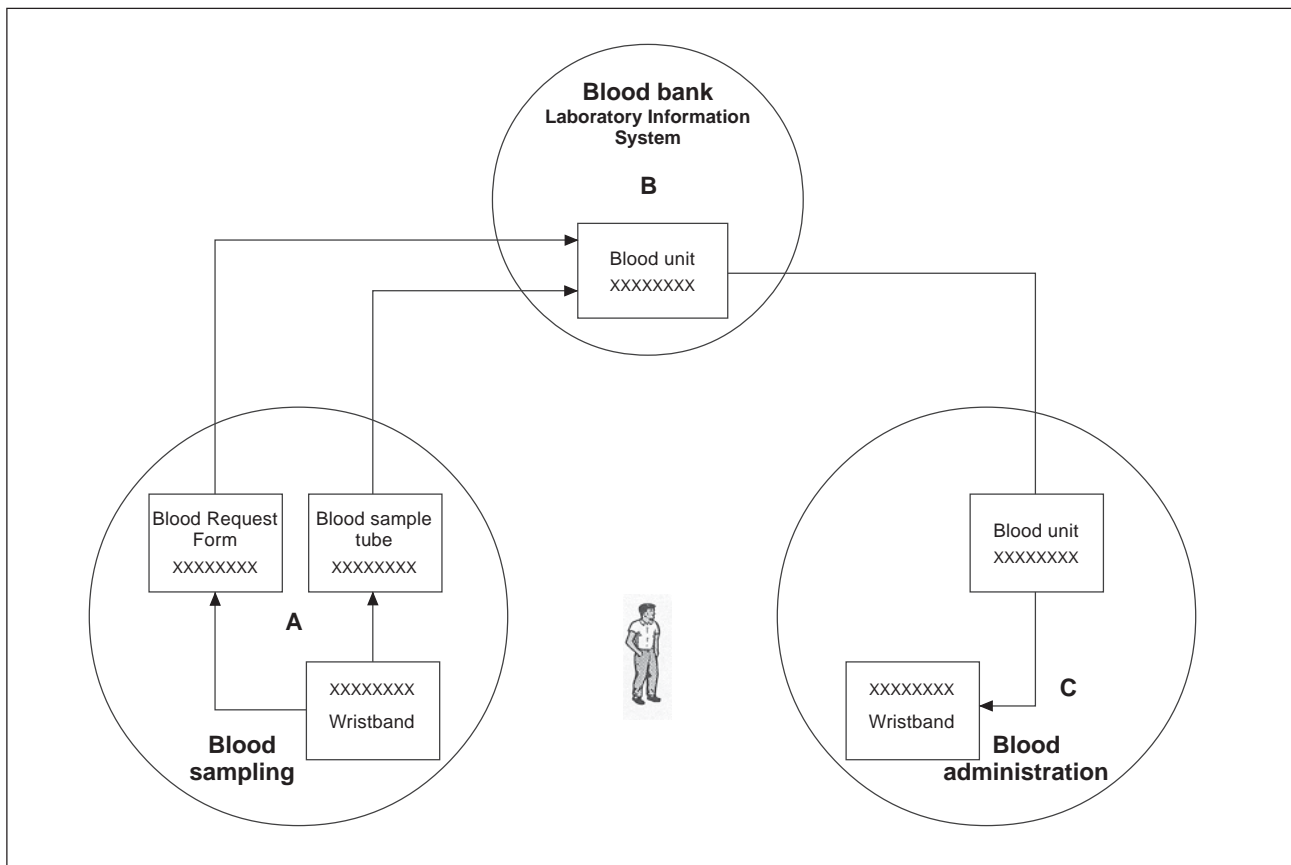

Fig 1. Verification and documentation of a patient's unique number XXXXXXXX during blood sampling (A), in the blood bank (B), and during blood administration (C)
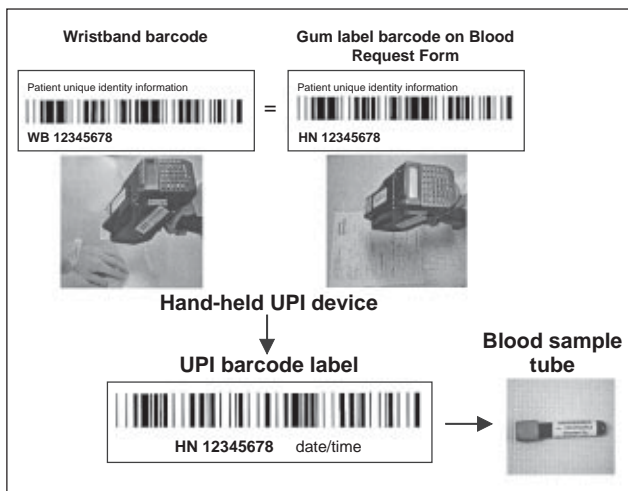
Fig 2. Verification and documentation of a patient's unique number using unique patient identification (UPI) device during blood sampling

Fig 3. Patient identification process using Laboratory Information System (LIS) in the blood bank
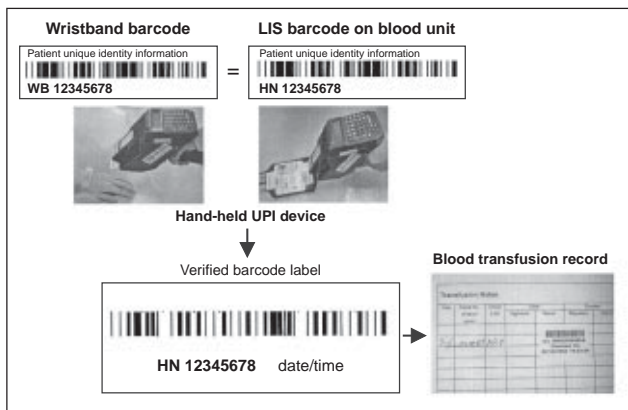

Fig 4. Verification and documentation of a patient's unique number using unique patient identification device during blood administration

System components
In all public hospitals in Hong Kong, each patient on admission is allocated a unique number: an eight-digit number with the prefix HN. This number is different for each admission, even for the same patient. This unique number, together with other unique identity information of the patient (name, sex, date of birth, Hong Kong Identity Card number, date and time of admission, and the admitting

department and ward), is produced from the hospital's computerised Integrated Patient Administration System (IPAS) and is printed out in the form of a rectangular, self-adhesive 'gum label' (3 cm x 6 cm). The patient's unique number also appears in a barcode format in the label. This unique number is used as patient's identity during his/her hospitalisation.

The electronic UPI system uses a computer linked to the IPAS to produce another label containing the same information as in the 'gum label'. It differs from the 'gum label' in two ways. The unique number has a prefix of WB instead of HN. It is linear in shape and is attached to the patient by means of a wristband throughout his/her hospital stay till discharge.

The tool used to verify and document the unique number during blood sampling and blood administration is a portable hand-held scan-and-print electronic device (PathFinder Ultra; Monarch UPN Alliance, Dayton, Ohio, United States). This device (weight: 1 kg) is stand-alone, battery-operated, and consists of three major components: a laser barcode scanner, a thermal label printer, and a display screen. The laser barcode scanner scans and verifies the barcodes to be processed or matched. The thermal label printer prints out and documents the matched results. The display screen shows the battery condition, error messages, time, and date.

System use
In pre-transfusion blood sampling, a member of the medical staff first checks the patient's identity on the wristband against that on the patient's gum label, affixes the gum label belonging to the patient onto the blood request form, and fills in the details on the form. The UPI device is then used to scan the patient's wristband barcode and the gum label barcode on the blood request form (Fig 2). If the two barcodes do not match, an error message is issued and the process of patient identification has to be repeated. If the two barcodes match, the UPI device will print a self-adhesive UPI label containing the barcoded unique number (prefixed with HN), together with the date and time of blood sampling. This UPI label is attached to the blood sample tube which, together with the completed blood request form affixed with the gum label, is then sent to the hospital blood bank.

On receiving the blood sample tube and the blood request form, hospital blood-bank staff first checks the information on the UPI label of the blood sample tube against that on the gum label of the blood request form, and then uses the LIS to scan the two labels. Only if the two are identical will further blood tests be processed. If a blood unit is to be issued, an LIS barcode label is generated and affixed onto the blood unit allocated to that patient. This barcode label contains the unique number (prefixed with HN), as well as the patient's other identity information (Fig 3).

At the bedside before blood administration, a member

Table. Comparison of the unique patient identification (UPI) system with the conventional second-checker system

	Second-checker system (May 1995 to April 1999)	UPI system (May 1999 to April 2002)
Cost		
Development	0	HK$1 250 000
Recurrent	0	HK$50 000/year
Effectiveness (No. of cases)		
Blood transfused to wrong patients	0	0
Wrong labelling of blood samples/request forms	13	0
Acceptance		
Time taken for one procedure (mins)	6	6
Compliance rate	90%	90%

of the medical staff checks the patient's identity on the wristband against that on the LIS label of the blood unit, as well as the blood group of the blood unit. The UPI device is then used to scan the patient's wristband barcode and the LIS label barcode (Fig 4). If the two barcodes do not match, an error message is generated and the process of patient identification has to be repeated. If the two barcodes match, a self-adhesive verified barcode label is generated by the UPI device. This label is then affixed onto the patient's blood transfusion record, and blood infusion can be started (Fig 4).

System implementation
This electronic UPI barcode system was initiated by the HTC in December 1997. It was implemented hospital-wide by a UPI Task Force in May 1999. The UPI Task Force consisted of HTC members, front-line medical and nursing staff, and representatives from the Hospital Information Technology Department. The project was supported by the Hospital Chief Executive who was also a member of the HTC.

Staff training for nurses and doctors took place at ward level. They were given written instruction and supervised by ward managers until they were competent with the UPI procedure. A proactive approach was adopted by the UPI Task Force to monitor the progress of the system implementation. Feedback opinions from staff were collected and analysed by the UPI Task Force in the quarterly HTC meetings. Towards the end of 3-year implementation, from February to April 2002, a survey was conducted to evaluate the performance of the UPI device. All staff using the UPI device for either blood sampling or blood administration had to record problems in a pre-prepared problem sheet. The scope of use of the electronic device, cost, effectiveness, staff acceptance and compliance rate, and problems of the UPI barcode system were then reviewed.

The conventional second-checker system remained as a contingency back-up system, which could be resorted to whenever staff encountered problems with the UPI device. By the conventional system, a gum label belonging to the patient is affixed onto the blood sample tube as well as to the blood request form. The process is verified by a second checker. In the blood bank, these two labels are checked

manually by the blood bank staff, and an LIS label is generated and affixed onto the blood unit. Before blood administration, a staff member checks manually the wristband label and the LIS label, and a second checker verifies the process.

Results

Scope of use of the UPI device
The electronic UPI device had a trial period of 9 months before being rolled out hospital-wide. It was used in all wards of the departments of medicine, paediatrics, general surgery, orthopaedic surgery, obstetrics and gynaecology, clinical oncology, intensive care unit, day service, as well as in the operating theatres. It was not used in the psychiatric wards where blood transfusion was rarely needed, and in the Accident and Emergency Department where a different system was used. One UPI device was placed in each ward. In all, 51 UPI devices including three spare ones were installed.

Cost
Initial capital cost for purchase and installation of computers and UPI devices amounted to HK$1 250 000. Recurrent costs—mainly battery maintenance and paper supply—averaged HK$50 000 per year.

Effectiveness and acceptance (Table)
From May 1999 to April 2002, no cases of blood transfusion to wrong patients or wrong labelling of blood sample tubes and blood request forms occurred with 41 000 blood sampling procedures and administration of 27 000 units of blood. In comparison, when the conventional second-checker system was implemented between May 1995 and April 1999, a total of 13 transfusion incidents involving wrong labelling of blood sample tubes or blood request forms were recorded.

Both the nursing and the medical staff found no difficulty in using the UPI device. New staff required supervision only during their initial two to three sessions of use. The overall compliance rate of using the UPI device for transfusion process approached 90%, as shown by the 2-month hospital-wide evaluation survey in 2002. In approximately

10% of cases, the conventional second-checker system had to be resorted as a back-up.

The survey also showed that on average, a house officer took 6 minutes to finish the blood sampling procedure using the UPI device. The conventional second-checker system required a similar time. Scanning and barcode printing normally took 30 seconds.

Problems and solutions

Problems encountered with the use of UPI device were formally analysed on completion of the 2-month hospital-wide evaluation survey. The survey results showed that problems occurred in 12% of episodes of use of the device, and that the majority of these problems were related to battery failure, which led to scanning and printing errors. End-users' chief comments were that the system still required staff signature and manual recording of the blood unit's serial number. Furthermore, the system could be fooled by scanning barcode labels bearing the same prefix—for example, scanning of the wristband label (prefix WB) plus either the LIS label or the gum label (both with the prefix HN) could generate a verified barcode label. This fault, however, did not happen in practice because there was no incentive for staff to depart from the scanning protocol.

On the basis of these findings, the HTC decided to tailor-make a second-generation UPI device. Design of the new device was based on the original model and emphasised handiness (weight: 0.5 kg), efficient scanning and printing mechanisms, and the use of rechargeable, cheaper batteries. The following new functions were incorporated: firstly, the verified barcode label contained an additional barcode of the serial number of the blood unit, so as to spare staff from recording the serial number manually on the patient's blood transfusion record, thereby eliminating documentation error and saving time. Secondly, both the verified barcode label and the UPI label included staff barcodes, thereby rendering staff signatures, which are often illegible, unnecessary. Thirdly, to prevent medical staff from scanning labels with identical prefixes, the prefix of the unique number in different stages of the transfusion process were serially changed by the electronic device (Fig 5). Fourthly, the device possessed a storage memory of 1000 registries which, when networked to the hospital computer system, could be available for further data analysis. Finally, additional modes of patient identification, such as for intravenous nutrition or chemotherapy administration, and for point-of-care patient testing, were incorporated.

Discussion

Our 3-year experience of the electronic UPI barcode system has demonstrated the feasibility of adopting a barcode patient identification system for transfusion process in an acute hospital setting in Hong Kong. Studies have shown that blood sampling and administration errors caused by circumstances related to workload are unlikely to be
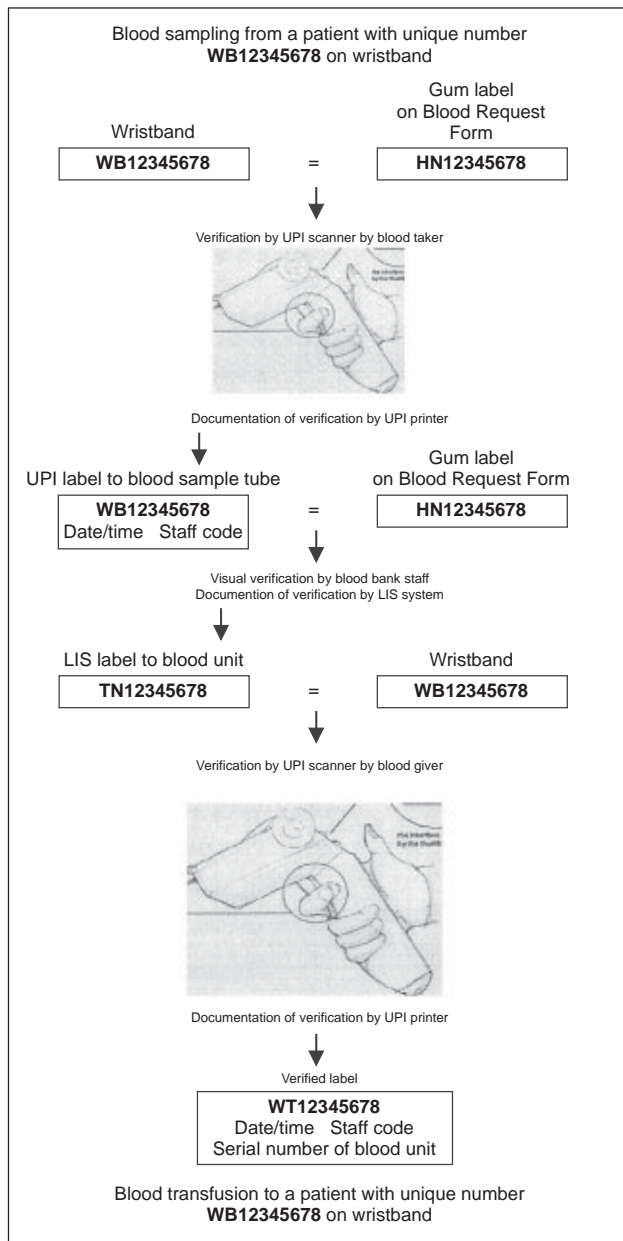

Fig 5. Tracking a patient's unique number from blood sampling to blood administration

prevented by written standard operating procedures or extensive in-service training.[1] The need to develop a comprehensive system that would provide a high likelihood of consistent and proper use, while including bedside verification of the identity match between patient and blood unit, is now being addressed by our electronic UPI barcode system. Although the reduction in patient identification errors achieved by our UPI system was small when compared with the second-checker system, our new system achieved its objective. It assisted medical staff to confirm that the patient from whom blood was to be taken was the same patient whose identity was specified on the blood request form and on the blood sample tube. Similarly, the new UPI system helped medical staff to verify that the unit of blood

prepared for the patient was given to the intended patient. A patient's unique number was used as patient's identity throughout the transfusion process. The system therefore improved the process of matching patient and blood unit—a critical step in transfusion medicine.

The feasibility of using the UPI device in various hospital settings suggested that the device is user-friendly. Both house officers and nursing staff found minimal or no difficulty in using the hand-held device. Although the time taken to perform blood sampling with the device was similar to that in the second-checker system, the UPI approach saved manpower because it required only one staff to complete the task whereas two staff were needed by the conventional second-checker system. In addition, the UPI system may have potential use in other areas where UPI is important.

The effectiveness, acceptance, and potential other uses of the electronic barcode device prompted the HTC and the hospital to improve the existing system. The second-generation device would circumvent the battery problem—the chief drawback of the first-generation UPI device, and would have upgraded functionality. Though the development of a new device would have cost implication, from a transfusion service perspective, the true benefit of introducing such a system calls for a proper cost-benefit analysis,[10] especially if one also takes into account of the legal costs associated with major transfusion incidents.

One point to note is that our electronic UPI barcode system is still unable to prevent error if a wrong patient is approached for blood sampling in the first instance. In that event, the wrong patient's unique identity would be used throughout the transfusion process. Accurate identification

of the intended patient remains a crucial first step in the transfusion process and relies entirely on medical staff's prudence and awareness of the importance of this step.

With concerted effort of the UPI Task Force, the HTC, hospital managers, and all clinical staff, it is hoped that, with time, the improved UPI barcode system would further improve the safety of transfusion practice and possibly other hospital procedures requiring patient identification.

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