Virtual Blood Banking

A 7-Year Experience

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Abstract

The operating theater blood transaction system (OTBTS) is a virtual blood banking system that allows computer crossmatch–compatible blood ordering and delivery in the operating theater remote from the hospital blood bank. It was developed and implemented in our hospital in 1997 and was expanded in 2002 to include an unmatched blood module that allows ordering and issuing unmatched RBCs for intraoperative transfusion. During the past 7 years, the system has handled 6,333 crossmatch requests for intraoperative transfusion and issued 20,073 units of RBCs, including 100 units of unmatched RBCs (group O, 72 units; group-identical, 28 units). The OTBTS has proven to be efficient (with a turnaround time for blood ordering and issuing <30 seconds), effective (with a reduced crossmatch/transfusion ratio and blood wastage), and error free (no delay or error in transfusion or postponement of operation). Furthermore, our experience with the unmatched blood module has attested to the safety and efficacy of computer-controlled, online ordering and real-time, on-site delivery of unmatched RBCs for emergency transfusion.

A major challenge to blood bankers is to provide real-time, zero-risk, and zero-wastage blood transfusion service, particularly for patients with active bleeding. Such a target can be achieved partly by the use of computer crossmatch. In computer crossmatch, electronic verification of the ABO blood group replaces the immediate-spin crossmatch for ABO incompatibility between donor RBCs and patient serum samples.\(^1\)

Computer crossmatch is considered a safer and more efficient system than the antiglobulin and immediate-spin crossmatch, provided that the ABO/Rh D blood group has been determined twice and the patient has no history of clinically significant antibodies.\(^1^4\) It has been estimated that the workload in the blood bank could be reduced by as much as two thirds compared with antiglobulin crossmatch.\(^2\) Furthermore, the computer crossmatch has drastically shortened the time required for obtaining compatible RBCs when transfusion is needed, thus allowing flexibility in the management of blood inventory and also minimizing blood wastage.\(^1^4\) Other measures include a portable blood-storage refrigerator or out-of-hospital transfusion,\(^6^7\) with the aim of bringing the blood bank facilities nearer to the patients.

In 1997, we developed a computer software system (the operating theater blood transaction system [OTBTS]) that provides “self-service” ordering and delivery of computer crossmatch–compatible RBCs by nonlaboratory personnel at sites remote from the hospital blood bank.\(^5\) The system is cost-effective, efficient, and user friendly. With the experience gained and confidence built on the OTBTS, the system has been developed further to provide emergency transfusion of unmatched RBCs for patients who do not yet have a valid type and screen (T&S) result. In this report, we review our 7-year experience with the OTBTS and its capability to provide a
safe and timely blood transfusion service and, in particular, the value and safety of real-time ordering and delivery of unmatched RBCs through the remote blood delivery system.

Materials and Methods

Blood Bank

The Queen Elizabeth Hospital, Hong Kong, China, is an acute care hospital with 1,800 beds and all major medical and surgical departments, including cardiothoracic surgery and traumatology units. Each year, the blood bank handles about 32,000 requests for compatibility testing and issues more than 25,000 units of RBCs for transfusion. Routine serologic compatibility testing (T&S and immediate-spin crossmatch) was replaced by computer crossmatch in August 1996, which led to improvement of the crossmatch/transfusion (C/T) ratio from around 1.7 to 1.5. The blood bank of Queen Elizabeth Hospital is situated in a separate building some distance from the operating theater (OT); the round trip requires 20 to 30 minutes. In view of the efficacy and safety of computer crossmatch, we implemented a computer system for self-service blood ordering and issuing in the OT in 1997.

Operating Theater Blood Transaction System

The software and hardware requirements have been described in a previous report. Briefly, the system has built-in logic to verify and confirm compatibility of the RBCs taken from the blood-storage refrigerator in the OT and ensure that only designated blood units are issued for transfusion in serologically complicated cases. The numbers of crossmatch requests and blood units issued (and transfused) through the OTBTS in a 7-year period from June 16, 1997, to June 15, 2004, were reviewed. The turnaround time (TAT) for blood ordering and issuing through the OTBTS, the C/T ratio, and the expiration rate of RBCs were recorded. The frequency, duration, and effects of computer downtime were monitored. All clerical, computer, and transfusion errors were documented and investigated.

Unmatched Blood Module

In 2002, the OTBTS was expanded to incorporate the logic for ordering and issuing unmatched RBCs for emergency transfusion. If the blood group of the transfusion recipient is not yet known, group O RBCs will be issued. If the blood group is known (with a historic record in the hospital laboratory information system) and has been confirmed from a current blood sample, the nursing staff will be instructed to take group-identical RBCs for transfusion and group O RBCs can no longer be issued. Once the blood bank has received and registered the patient’s blood sample and the T&S is being performed, a real-time indication of the expected time for completion of the T&S and availability of computer crossmatch–compatible RBCs (except for cases with a positive T&S result) will be given by the latter is estimated from the registration time of the blood sample and the promised TAT of T&S. This information can help decide whether one can wait for the T&S result and computer crossmatch–compatible RBCs. A computer printout (with the patient’s data and blood group if available and the blood group of the unmatched blood unit) will be issued to the anesthesia provider for confirmation and signing.

Similar to the release of computer crossmatch–compatible RBCs through the OTBTS, there is no additional tagging or labeling of the unmatched blood unit. The blood bank will be alerted if unmatched RBCs have been issued. Unmatched RBCs will not be issued through the OTBTS if the patient is younger than 4 months or known to have a Rh D-negative phenotype, alloantibody, or ABO anomaly.

The system logic was written according to the current practices in the blood bank and international standards. The system was tested, validated, and fully implemented on April 10, 2002. The use and efficacy of the unmatched blood module from April 10, 2002, to June 15, 2004, are reviewed.

Results

During the 7-year period, 20,073 units of RBCs were issued for 6,333 patients for intraoperative transfusion through the OTBTS. Of these, 1,099 units were returned to the blood bank after being issued. The system rejected 62 of these units for reissuing because they had left the blood-storage refrigerator for more than 30 minutes. Thus, the wastage rate for the OTBTS was only 0.31%, and the C/T ratio was 1.06:1.

The amount of RBCs issued through the OTBTS constituted approximately 11% (20,073/181,599) of the total amount of RBCs and whole blood transfused in the hospital during the study period. The TAT for blood ordering and issuing from the OTBTS was less than 30 seconds, even when multiple blood units were issued. No transfusion incident (including delay) or postponement of operation occurred, and no transfusion error was reported in the OT during this period.

A 4-hour computer downtime was scheduled monthly for preventive maintenance of the network and other hardware components of the hospital laboratory information system, usually at midnight or early on Sunday morning when there were no scheduled operations. Unscheduled computer downtime was exceedingly rare for the OTBTS, and intraoperative blood transfusion was never affected. A documented manual backup system for blood ordering and issuing was in place during computer downtime, with retrospective entry of all transactions.
Unmatched blood requested

Patient identification

If the patient is/has:
(a) <4 months old or 
(b) known to be Rh D negative or 
(c) a previous record of alloantibody or 
(d) a previous record of ABO anomaly

Yes

Contact blood bank

No

Current ABO/Rh D

Known

Historical ABO/Rh D if available

Different

Antibody screen result

Positive

Contact blood bank

Negative

Computer crossmatch compatible RBCs

Unmatched group identical RBCs

Unknown

In progress

Contact blood bank

Unmatched group O RBCs

Figure 1 A flowchart showing the algorithm for ordering and issuing unmatched RBCs through the operating theater blood transaction system.

Figure 2 If an emergency transfusion is required before the availability of the type and screen result, group O RBCs (A) or group-identical RBCs (B) can be issued, depending on whether the patient’s blood group is known.
Since the development of the unmatched blood module of the OTBTS, 72 units of unmatched group O RBCs and 28 units of unmatched group-identical RBCs were issued to 33 patients for intraoperative transfusion. This represents 14.3% of all unmatched RBCs transfused in the hospital during the study period (100/700). Emergency transfusions using computer crossmatch–compatible RBCs instead of unmatched RBCs eventually were given to 2 patients with the knowledge that T&S could be completed within a short time. The average number of units of unmatched RBCs for each request issued through the OTBTS was 3, compared with 3.2 for the whole hospital. Only 8 units of unmatched RBCs were returned through the OTBTS and within 30 minutes of issue. Compared with the past, the total number of requests for unmatched RBCs and the total amount of unmatched RBCs transfused for the hospital have decreased since introduction of the OTBTS, with further improvement after the implementation of the unmatched blood module. The return rate of issued unmatched blood dropped from 21.8% to 13.6% after the implementation of the unmatched blood module. No transfusion errors were observed.

Discussion

Although computer crossmatch was first described by Butch et al in 1994, it has not been practiced widely, with only 4% of hospitals in the United States using computer crossmatch when no alloantibody was detected. The capability of blood bank computerization, therefore, has not been realized fully and its versatility not wholly explored.

In 1997, our hospital implemented a computer-based system for remote ordering and on-site issuing of computer crossmatch–compatible RBCs in the OT. The system is able to shorten markedly the time of blood delivery to the OT, reduce the C/T ratio, and reduce the blood inventory and wastage. The TAT for obtaining compatible RBCs for intraoperative transfusion has decreased from more than 30 minutes to less than 30 seconds, even when multiple units of RBCs are ordered and issued at the same time. The quality of blood stock can be improved, because the blood units that have left the blood-storage refrigerator for more than 30 minutes will be discarded, in accordance with international guidelines.

During the past 7 years, there were no delays in transfusion or postponement of surgical operations due to problems or
downtime of the OTBTS. Several known problems associated with satellite blood banks and remote blood-storage facilities have been described, such as blood for multiple patients stored in the same refrigerator and inadequate stock on hand during an emergency, resulting in using blood for other patients. The OTBTS can solve these problems by taking full advantage of computer crossmatch, ie, immediate availability of compatible RBCs without the need for previous allocation of blood units to designated patients, allowing the controlled use of any group-identical RBCs, real-time inventory monitoring, and early stock replenishment.

In 2002, we implemented a novel module for remote online ordering and immediate on-site delivery of group O or group-identical unmatched RBCs. The interval between prescribing the emergency transfusion and delivery of the unmatched RBCs to the OT is less than 1 minute. The requesting clinician (usually the anesthesia provider) does not need to call the blood bank or complete a request form ordering unmatched RBCs. Keeping the clinician informed of the progress of the T&S facilitates decision making in emergency intraoperative transfusions and reduces the need for unmatched blood transfusion. Thus, the OTBTS can ensure timely, safe, and appropriate blood transfusion during an emergency and allow documentation and traceability of the unmatched RBCs ordered and issued.

Our results also show that approximately 1.1% (100 of 8,820 units issued through OTBTS) of intraoperative transfusions required unmatched blood and about 3 units of RBCs are given for each episode of unmatched blood transfusion. Of interest, after implementation of the unmatched blood module, the number of requests for unmatched RBCs and the number of unmatched blood units transfused or returned have dropped. This observation confirms that increased autonomy of clinicians and enhanced accessibility of blood products will not lead to increased blood use,8 but rather to more rational requests and use because an “unlimited” supply can practically be instantly assured.

The OTBTS can be viewed as an extension of the computer crossmatch and blood bank porter service, with the use of non-laboratory personnel for blood ordering and issuing in the OT. Immediate availability of computer crossmatch–compatible and controlled release of unmatched RBCs are made possible by the system. The hardware and software (such as database licensing) costs are not substantial. The system is considered easily maintainable by the informatics team. At least 1 full-time equivalent costs are not substantial. The system is considered easily manageable. The hardware and software (such as database licensing) costs are not substantial.

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To conclude, the OTBTS has proven to be safe, efficient, and cost-effective. The success of the OTBTS is, however, dependent upon designated and dedicated staff with appropriate training, on-site bar-code data entry and checking, and “real-time” response, feedback, and monitoring.

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References