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IN MEMORIAM: SANDRA SUE ELLISOR

This issue is dedicated to the memory of Sandra Sue (Sandy) Ellisor, who worked for the American Red Cross from 1976 until 1991. During that time, Sandy became one of the founding editors of *Immunohematology*. She remained on the editorial board for more than 20 years.

Sandy was dedicated to blood banking and was especially interested in management issues. This issue focuses on such management topics as choosing automated instruments for the transfusion service, establishing a transfusion service disaster plan, moving an immunohematology reference laboratory, and using group O red blood cells during massive transfusion. In addition, several members of the editorial board share their memories of Sandy and include a tribute to Sandy as both a connoisseur of wine and a skilled blood banker.
Automation in the transfusion service

S.H. Butch

Several instruments are now available for full automation of serologic testing in the transfusion service. Selection of an instrument is based on the facility's needs for testing and its resources. Installation, validation, interfacing, and operations require new skill sets for most transfusion service personnel. The newer instruments are suitable for use in smaller transfusion services, where procedures may not have changed recently and installing new equipment is a rarity. It is difficult to compare turnaround times and the cost of operating the instrument because the number of specimens and specific tests per run and test optimization features of the instrument's software all can vary. Automated instruments have proved to be suitable for testing most, but not all, specimens submitted for testing. While automation reduces overall turnaround time, the quickest way to determine a patient's blood type remains the manual tube test. Autoverification of results and placing these instruments in an automation line in a core laboratory may lie in the future. Immunohematology 2008;24:86–92.

Key Words: pretransfusion testing, crossmatch, compatibility testing, automation, validation, transfusion service

Automation of serologic testing has many advantages, including improved quality management. With fewer manual steps, standardization of testing, and the ability to review saved images of test results, errors are reduced and problems are more easily traced. While a few automated and semiautomated instruments have been available for more than 10 years, instruments that perform a full range of testing and are suitable for use in the transfusion service have been available in the United States only in the last 5 years. There now are available a number of systems to perform automated serologic testing in the transfusion service. Purchasing, installing, validating, and using automation present challenges to transfusion service personnel more familiar with manual testing.

Transfusion Service Instrumentation

Three manufacturers currently make available four instruments for use in a transfusion service in the United States. Table 1 lists the instruments and various attributes. The information in this table was obtained from a variety of sources and is believed to be current at the time of this writing. However, new capabilities may have been introduced and additional testing and features may now be available. Not included in this list are semiautomated instruments, those that perform ABO and D typing only or antibody screening only, and instruments that are no longer marketed and supported by their vendors.

The currently available instruments perform ABO and D typing, antibody screening, antibody identification, antigen typing, donor ABO/D reconfirmation, and direct antiglobulin testing (DAT). Some instruments perform IgG crossmatching. Each instrument is unique and their platforms (solid phase, gel column, and microtiter plates) differ. The Galileo (Immucor, Norcross, GA) appears to be an instrument suited to a blood bank that both collects donor units and performs pretransfusion testing. The Echo (Immucor), ProVue (Ortho-Clinical Diagnostics, Raritan, NJ), and Tango Optimo (Biotest Diagnostics, Rockaway, NJ) are intended primarily to be used in a transfusion service, but they could be used in facilities that collect a smaller number of donor units.

Selection

The transfusion service now joins the other sections of the clinical laboratory vying for large capital equipment funding. However, our colleagues in the other laboratory sections can provide useful information about the process of selecting, financing, installing, validating, and operating instrumentation. Table 2 lists a number of issues to be considered in the selection process.

Instrument selection is based on the individual institution's needs and available resources. Developing a list of operating needs, such as turnaround time,
## Table 1. Instrument features

<table>
<thead>
<tr>
<th>Test menu</th>
<th>Galileo</th>
<th>ECHO</th>
<th>ProVue</th>
<th>Tango</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABO</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Antibody screen</td>
<td>Pooled, 2-cell, 3-cell, 4-cell</td>
<td>3-cell plus control</td>
<td>Pooled, 2-cell or 3-cell</td>
<td>Pooled, 2-cell or 3-cell</td>
</tr>
<tr>
<td>Antigen typing Rh phenotype</td>
<td>Rh phenotype</td>
<td>Rh/Kell phenotype</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Panels</td>
<td>Yes, 3 precoated panels available</td>
<td>Yes, precoated panels available</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other testing Weak D, DAT, CMV, syphilis</td>
<td>Weak D, DAT</td>
<td>Weak D, DAT</td>
<td>Weak D, DAT</td>
<td>Weak D, DAT</td>
</tr>
<tr>
<td>Crossmatch</td>
<td>IgG</td>
<td>IgG</td>
<td>IgG</td>
<td>IgG</td>
</tr>
<tr>
<td>Unit ABO/D confirmation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Platform</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor model</td>
<td>Benchtop</td>
<td>Benchtop</td>
<td>Benchtop</td>
<td></td>
</tr>
<tr>
<td>Hemagglutination for antigens and solid phase for antiglobulin phase</td>
<td>Hemagglutination for antigens and solid phase for antiglobulin phase</td>
<td>Gel</td>
<td>Dried antisera in wells for antigens, Solid screen II for antiglobulin phase</td>
<td></td>
</tr>
<tr>
<td>Fully automated</td>
<td>Fully automated</td>
<td>Fully automated</td>
<td>Fully automated</td>
<td></td>
</tr>
<tr>
<td>Continuous access via linear sample and reagent racks</td>
<td>Continuous access via linear sample and reagent racks</td>
<td>Batch or single specimen</td>
<td>Single specimen stat capability</td>
<td></td>
</tr>
<tr>
<td>Dynamic scheduler</td>
<td>Image analysis reader</td>
<td>Image analysis reader</td>
<td>Stat interrupt capability</td>
<td>3-color CCD camera</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System liquid</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PBS</td>
<td>PBS</td>
<td>Gel card diluent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can be filled while instrument is processing</td>
<td>Can be filled while instrument is processing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can accommodate a 20L saline cube</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specimen</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen type</td>
<td>EDTA</td>
<td>EDTA</td>
<td>EDTA, citrate, and serum</td>
<td>EDTA, citrate, and serum</td>
</tr>
<tr>
<td>Specimen size</td>
<td>12–17 mm diameter, 75–100 mm length, pediatric microtainers</td>
<td>12–16 mm diameter, 75–100 mm length, pediatric microtainers</td>
<td>12–16 mm diameter, 75–100 mm max</td>
<td>10–16 mm diameter, 105 mm high, pediatric containers</td>
</tr>
<tr>
<td>Sample capacity</td>
<td>224, continuous feed</td>
<td>20, continuous feed</td>
<td>12 per run; 48 per carousel</td>
<td>144 samples in 12 racks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Turnaround time</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time for first ABO/D</td>
<td>22 minutes</td>
<td>11 minutes</td>
<td>35–40 minutes</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Time for antibody screen</td>
<td>40 minutes</td>
<td>20 minutes</td>
<td>35–40 minutes</td>
<td>31 minutes</td>
</tr>
<tr>
<td>Specimens/hour</td>
<td>Variable, dependent on number of samples and test mix; average of 60 type and screens/hour</td>
<td>Variable, dependent on number of samples and test mix; average of 16 type and screens/hour</td>
<td>Variable, dependent on number of samples and test mix</td>
<td>12 type and screens/64 minutes</td>
</tr>
<tr>
<td>STAT time</td>
<td>Variable</td>
<td>Variable, typically less than 45 minutes</td>
<td>Variable</td>
<td>Has two stat functions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interface</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unidirectional interfaces to LIS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bidirectional interfaces to LIS</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Host query</td>
</tr>
</tbody>
</table>
Table 1 continued. Instrument features

<table>
<thead>
<tr>
<th>Galileo</th>
<th>ECHO</th>
<th>ProVue</th>
<th>Tango</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality controls available</td>
<td>Yes, premanufactured</td>
<td>Yes, premanufactured</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Whole blood daily run controls can be processed with samples</td>
<td>Once daily</td>
<td>Once daily</td>
</tr>
</tbody>
</table>

Table 2. Considerations in instrument selection

- Platform and test methods
- Physical space and electrical requirements
- Tests to be automated
- Stat processing capability
- Backup testing method and costs
- Routine turnaround time
- Quality control requirements
- Cost for operation
- Ease of operation
- LIS* interface capability and cost
- Training requirements and costs
- Vendor assistance in validation and training
- Maintenance and service agreements
- Mean time between failures (if current operational data are available)

*Laboratory information system

Stat capability, cost, specificity, and sensitivity, is essential to selecting the correct instrument and measuring the effectiveness of the process after implementation.

Quality assessment tools and Lean concepts, if applied from the early planning stages through postimplementation assessment, assist in redefining processes, selecting performance measures, and evaluating goals. Defining the current process as well as the proposed new process is a necessary planning step. Before-and-after layouts of the flow of specimens and information help identify needs for space reconfiguration, computers, new furniture, and the location of reagent storage. For budgeting purposes, these expenses may be combined into the instrument acquisition cost or funded separately, depending on the budgeting process the facility uses.

Conducting site visits to and telephone interviews of current users are helpful in identifying valuable features and actual user experience in routine operation of the instrument. Providing the facility being queried with a list of questions based on the anticipated use of the instrument allows this facility
to gather data and provide a more accurate response. Another resource is a Web search for current published abstracts and papers, using PubMed. And the Web site http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/search.CFM can be used to investigate problems with various instruments reported in the MedWatch program. The listings can provide insights into user problems, installation issues, and repair problems. Note that there is a correlation between the number of instruments in the field and the number of reports.

Choosing the platform, microtiter plate or gel column, is a major decision. While gel seems to be more sensitive to Rh and warm autoantibodies, solid phase and microtiter seem to be more sensitive to cold-reactive antibodies. Both microtiter plate and gel column platforms have been reported to miss a clinically significant antibody, supporting the long-held belief that no one technique will identify all antibodies.

### Interfacing

All of the instruments are capable of being interfaced with one or more laboratory information systems (LIS). There are additional costs for interfacing instruments with a LIS. Each interface is considered unique and LIS vendors usually charge per instrument interfaced. The learning curve has been very steep for the first facilities attempting to interface instruments. None of the interfaces are easy and “plug and play” does not exist. As more instruments are interfaced, interfacing should become easier. Current users of the same instruments and same specific versions of LIS software are the best resource for learning about issues in interfacing that software-instrument pair. However, even when using the same equipment vendor and transfusion service software, setting up each interface can present new challenges because facilities operate differently. Options within the transfusion service software such as decision tables and other features (i.e., whether the ABO/D interpretation, the individual detail results, or both are sent) may be set differently for different facilities.

### Turnaround Times

It is difficult to compare turnaround time between instruments as it depends on the number of specimens being processed and the tests being performed. Instruments differ in the number of specimens with different testing requirements that can be run at the same time. Some instruments allow specimens to be run as a priority, or stat. The instrument software then optimizes the output of results for this specimen. This may or may not result in a significant reduction in processing time. Manual tube testing still provides the fastest method of obtaining a type and screen. However, the average turnaround time for a test will decrease and it is likely that most specimens can be run on the automated instruments, even if they are marked stat.

### Estimating Costs

Probably the most difficult aspect of the investigation process is estimating the cost of operating the instrument. Expenses vary widely and depend on the number of tests in the average run; the number of wasted wells in microtiter plates; the frequency and number of controls that must be run; the cost of reagents and diluents, which vary with contract tiers; and the number of repeat tests performed. Additional costs are associated with remodeling the workplace and service contracts. While automation has been marketed as a way of reducing total costs by reducing the number of staff members in a transfusion service, it is unlikely that staff members will be eliminated. Automation will improve process control and quality management, reduce stress, provide the ability to absorb additional testing, and allow re-allocation of staff to other projects such as increased quality monitoring.

Critical to the selection process is the backup testing process used when instrumentation is not operational. Even if there is no downtime for instrument malfunction, there is periodic maintenance and there may be a need to test specimens that some instruments cannot process due to specimen quantity or quality (severe lipemia, hemolysis). If the manual tube method using a 5% RBC suspension is used to back up an automated system using 0.8% RBCs in a gel system, two sets of RBCs must be stocked. Larger institutions may consider purchasing two instruments, as this is the ideal backup system. But even then, a manual backup system should be in place.

### Computer and Interface Issues

It may be necessary to make changes in the computer system to accommodate automated testing. If multiple instruments are used to perform testing, the instrument used for a specific test must be traceable. While a footnote on an order or test result
could work, it is probably best to build the tests in the LIS so that the result can be identified as coming from a specific instrument, as is done in the general laboratory.

Of critical importance is determining whether the automated instrument or the LIS interprets the testing results. For the LIS to interpret results, the individual test results (4+, 0, hemolysis, etc.) must be sent to the LIS. The value of using the LIS to interpret results is that the interpretation is controlled by the laboratory, not the instrument vendor. For example, it may be the policy of a hospital to interpret a weak D reaction as D− where the instrument might interpret it as D+. If the instrument sent only the interpretation, the algorithms set up in the LIS to meet the institutional policies would not operate. The validation strategy is influenced by which device interprets the results.

As our colleagues in donor centers have long appreciated, interfacing instruments to an information system can be frustrating, taking a year or more. This is especially true if the interface between that LIS version and the specific instrument has not been done previously.

Unidirectional and bidirectional interfaces may be used. In the unidirectional interface, test results are uploaded after being completed. The bidirectional interface downloads data on ordered tests and uploads the results. Middleware may be needed in some cases to translate the information sent by the instrument to a format understandable to the LIS. The process flow changes depending on whether the instrument is interfaced as well as on the type of interface. Whenever data are entered manually, there should be an ongoing process to ensure that they are entered correctly.

The Test Specimen

If the institution is still using a clotted specimen for testing blood bank specimens, a significant hurdle may be changing to an EDTA tube. Pink-stoppered EDTA tubes are available. They assist in separating tubes intended for hematology from those intended for the transfusion service. In addition, pink-top tubes have a larger specimen volume than the lavender tubes. Test requisitions, computerized test order sets, paper and online test information, and job aids all must be changed to reflect test mnemonics and specimen type changes. To prevent specimen redraws and delays in patient care, a process to manually test specimens should be considered, at least initially. The transition to an EDTA tube may be accomplished in anticipation of automation and need not be delayed until automation is implemented.

Validation

Vendors provide installation instructions and recommendations for verification of instrument operations. Testing should include a sufficient number of positive and negative antibody screens; various ABO and D types, including specimens with dual populations; and a comparison of results with those obtained using the current method. The validation should also include a provision for how discrepant results will be resolved. Obtaining an adequate number of different specimens with clinically significant antibodies with which to perform sensitivity and specificity assessments can be challenging. Freezing samples known to be positive in anticipation of instrument validation may be helpful. However, not all antibodies store well.

Vendors do not provide a plan to assess the instrument’s operation in terms of meeting the facility’s needs. Actual operating costs, turnaround time, instrument repair history, and staff ability to operate the instrument should be assessed initially and periodically during operations. Automation changes the workflow. Actual operations will provide information about the optimum time between runs, the most efficient number of specimens per run, a process for changing reagents (because of maximum time limits on the instrument), which shift should routinely do quality control and maintenance, and a process for “rotat(ing) control material testing among all operators who perform the test.”

Clinical Laboratory Improvement Amendments (CLIA) regulations require that testing be performed according to the manufacturer’s direction. This includes following the manufacturer’s instructions for quality control and periodic maintenance. When two instruments are used, results obtained on the same specimens from both instruments should be compared.

The Clinical and Laboratory Standards Institute (CLSI) has published standards for validation of quantitative tests. While these standards do not directly address compatibility testing methods they provide insight into planning validation studies. Reviewing protocols from other instrument users is helpful.
While combining training and validation to reduce the costs for reagents may seem appealing, it is best to provide learners with a positive training experience. Problems may occur during validation testing that can frustrate the learner. It may be more beneficial to have a few subject matter experts initially validate the instrument. The additional knowledge they gain from operating the instrument will better prepare them to conduct training.

Service

Instruments do break down. Probably the most common problem is a bent probe because the operator failed to remove a specimen or reagent closure. Some instruments allow the user to change probes and replace some parts. For all other repairs, a service call is needed. Service contracts are available for most instruments. These have variable costs and maximum response times.

Training and Competency Assessment

Initial training of staff is most often accomplished by sending selected staff members to an offsite training class. This creates superusers who are instrument experts. A number of individuals should be trained to this level. It may be useful to separate implementation into stages. Once staff are comfortable with performing ABO and D typing and antibody screening, other testing such as DAT, antigen typing, IgG crossmatch, and donor ABO/D reconfirmation may be added in phases. Some staff will find automation quite challenging and all the various options may be overwhelming.

Vendors supply training materials such as videos, manuals, and assessment aids but actual practice in running the instrument is needed. This is costly in terms of reagents and time. Performing training on a test system interfaced with a computer can be challenging. Creativity is needed to simulate problems and activate warning messages to provide the operator with real-life practice. Using screenshots or pictures in training materials and in written or computerized quizzes is invaluable in creating the scenarios to assess problem solving skills. Direct observation of staff performance is needed to determine whether the trainee has acquired appropriate psychomotor skills and can perform appropriate instrument operations.

Postimplementation Assessment

After implementation it is likely that changes will be needed to improve operations or training and ameliorate any negative unintended consequences. The quantity of reagents needed routinely, frequency of testing to maintain staff competency, and other logistics will only become evident after operating for a few months. Ongoing assessment of operations and problems will provide data for revising procedures to reduce operator errors, requesting instrument enhancements, and evaluating replacement instruments.

Conclusion

While still relatively new to the transfusion service, automation of transfusion service serology has proved itself to be a valuable tool. The devices available are likely to work well in most transfusion services. Although no system is currently available that will run on an automation line of a core laboratory, there is hope for the future. The development of more sophisticated software that includes auto-verification protocols is needed to further reduce the hands-on time the systems require and increase their efficiency.

References


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Transfusion service disaster planning

K. L. Bundy, M. L. Foss, and J. R. Stubbs

The Mayo Clinic, in Rochester, Minnesota, recently set forth a directive to develop a Mayo Emergency Incident Command System (MEICS) plan to respond to major disasters. The MEICS plan that was developed interfaces with national response plans to ensure effective communication and coordination between our institution and local, state, and federal agencies to establish a common language and communication structure. The MEICS plan addresses multiple aspects of dealing with resource needs during a crisis, including the need for blood and transfusion medicine services. The MEICS plan was developed to supplement our current local emergency preparedness procedures and provide a mechanism for responding to the escalating severity of an emergency to deal with situations of a magnitude that is outside the normal experience. A plan was developed to interface the existing Transfusion Medicine disaster plan standard operating procedures (SOP) with the institutional and Department of Laboratory Medicine (DLMP) MEICS plans. The first step in developing this interface was defining MEICS. Other major steps were defining the chain of command, developing a method for visually indicating who is “in charge,” planning communication, defining the actions to be taken, assessing resource needs, developing flowcharts and updating SOPs, and developing a blood rationing team to deal with anticipated blood shortages. Several key features of the interface and updated disaster plan that were developed are calling trees for response personnel, plans for relocating leadership to alternative command centers, and action sheets to assist with resource assessment. The action sheets also provide documentation of key actions by response personnel.

**Immunohematology 2008;24:93–101.**

**Keywords:** transfusion, emergency, disaster, planning

Mayo Clinic Rochester identified the need to develop and implement an emergency response and command system that was both flexible and scalable to a variety of disasters and emergencies. The need for flexibility and scalability in such a response plan is reflected in the Joint Commission’s revised emergency management standard that has recently been implemented:

Effective January 1, 2008, the emergency management standards (EC.4.10 and EC.4.20) for hospitals, critical access hospitals and long term care facilities have been revised to reflect an “all-hazards” approach to emergency preparedness that permits appropriately flexible and effective responses. The revised standards emphasize a “scalable” approach that can help manage the variety, intensity, and duration of the disasters that can affect a single organization, multiple organizations, or an entire community. They also stress the importance of planning and testing response plans for emergencies during conditions when the local community cannot support the health care organization. Over the past five years, the Joint Commission has studied a variety of disasters that impacted health care organizations, including floods, widespread electrical utility outages, the terrorist attacks of September 11, the four back-to-back Florida hurricanes of 2004, and the Katrina and Rita hurricanes that struck the Gulf Coast in 2005. In formulating these standards changes, the Joint Commission was debriefed by health care organizations affected by these disasters, engaged emergency management experts, served on national emergency management panels, and reviewed the current literature on emergency management. From these studies, the Joint Commission concluded that it is not sufficient to require that health care organizations plan for a single event; they should be able to demonstrate sufficient flexibility to respond effectively to combinations of escalating events.

At the 2007 AABB annual meeting in Anaheim, California, we briefly described the interface we developed between the Transfusion Medicine disaster plan and the institutional Mayo Emergency Incident Command System (MEICS) plan. In the following report, we detail further the MEICS plan that was developed to interface with national response plans to ensure effective communication and coordination between our institution and local, state, and federal agencies to establish a common language and communication structure. We also describe how we modified our existing Transfusion Medicine disaster plan SOP to integrate with the institutional MEICS plan while at the same time maintaining flexibility and scalability to deal with a variety of emergency and disaster responses.
Methods

Defining the MEICS

The MEICS provides a standardized approach to managing emergency situations, internal crises, and external disasters. MEICS employs a logical customized management structure, defined job responsibilities, clear reporting channels, and a common nomenclature to expedite decision making and help unify Mayo Clinic with other emergency responders. MEICS is a leadership team, which is activated only when an emergent situation surpasses the normal operating capabilities of the institution or departments. When MEICS is activated, new lines of authority are enacted, with all sections taking direction from the MEICS incident commander, either directly or via the MEICS section chiefs and unit leaders.

Following down the chain of command through the operations chief, the ancillary services director provides direction to all laboratory divisions through the laboratory unit leader. Our challenge was to develop the interface between Transfusion Medicine and the laboratory unit leader so that the Transfusion Medicine disaster procedure could be modified to accommodate institutional needs (Fig. 1).

Interfacing the Laboratory and Institutional MEICS

Multiple meetings were held with all divisions of Laboratory Medicine, including Transfusion Medicine, to define how to interface with the institutional MEICS plan and the laboratory unit leader. The process that was developed has several key features that allow for flexibility, including the ability to relocate MEICS leaders away from their normal worksites. Upon activation of the MEICS plan, the ancillary services director will assign one of the laboratory operations managers to serve as the laboratory unit leader. If the laboratory unit leader needs to relocate to the Institutional Command Center, a second operations manager will be contacted and asked to serve as the onsite leader for the departmental laboratories, as shown in Figure 2.

Who’s in Charge?

MEICS leaders will don red vests to visually indicate their responsibility for being “in charge” in the chain of command. This visual indicator was felt to be important because the command structure of MEICS is different from the chain of command used in normal daily laboratory operations, with which personnel have great familiarity. For example, the Transfusion Medicine medical director who is “in charge” during normal operations will not be the decision maker or information manager during a MEICS activation. Management personnel in Transfusion Medicine will be visually reminded of this difference by the presence of the red vest. One of the key lessons learned during the Katrina hurricane disaster was that there should be one single conduit through which all information and decisions flow to maintain command and control in emergency situations. Poorly defined roles and control mechanisms were cited by the White House as major flaws in the response to Hurricane Katrina:

In terms of the management of the Federal response, our architecture of command and control mechanisms as well as our existing structure of plans did not serve us well. Command centers in the Department of Homeland Security (DHS) and elsewhere in the Federal government had unclear, and often overlapping, roles and responsibilities that were exposed as flawed during this disaster. The Secretary of Homeland Security is the President's principal Federal official for domestic incident management, but he had difficulty coordinating the disparate activities of Federal departments and agencies. The Secretary lacked real-time, accurate situational awareness of both the facts from the disaster area as well as the on-going response activities of the Federal, State, and local players.3

Institutional and Departmental Communication Planning

Once the MEICS plan has been initiated at Mayo Clinic, the laboratory unit leader will assess the situation and begin contacting the various laboratories in a tiered fashion, using a calling tree. The calling tree is reviewed quarterly for accuracy. Authorized users can obtain it by contacting the Mayo Clinic telephone operator. Authorized individuals can also access the calling tree via a Web page. The calling tree contains contact information for the various laboratory medical directors, operations managers, administrators, and departmental leadership. The MEICS calling tree allows laboratory response personnel to be contacted in a tiered fashion based on likelihood of need. For example, Transfusion Medicine is designated as a tier 1 responding laboratory because of the high likelihood of blood and blood products being required in mass-casualty emergencies. In contrast, the likelihood of an immediate need for experimental pathology services during any sort of emergency is extremely low, resulting in a tier 4 designation for that department. The tiered approach to contacting personnel
Fig. 1. Mayo Emergency Incident Command System (MEICS) Management Structure

MEICS uses a logical customized management structure to establish new lines of authority to provide a mechanism for responding to the escalating severity of an emergency to deal with situations of a magnitude that is outside Mayo Clinic’s normal experience. An interface needed to be established between Transfusion Medicine and the laboratory unit leader. The laboratory unit leader reports to the ancillary services director. The ancillary services director reports to the operations chief, who ultimately takes direction from the incident commander.
also minimizes unnecessary responders placing undue burden on the response plan infrastructure and resources. In case response personnel cannot be contacted, the calling tree also provides a pool of alternative contacts. Lastly, the calling tree serves as a centralized source for up-to-date contact information for response personnel, as shown in Figure 3. Phone lines may become overloaded during an emergency, and alternative means of communication may be necessary. Text messaging has the advantage that it transmits at a lower bandwidth than a cell phone call. The MEICS phone lines in the various command centers are dedicated lines with limited access. Alternatively, landline calls and wireless forms of communication can be prioritized by contacting the National Communication Systems. Mayo has received Government Emergency Telecommunications Services (GETS) cards for use with MEICS. These provide a priority rating on phone calls. Two-way radios can also provide another means of communication outside of normal phone-based systems for use by key response personnel.

Taking Action during a Disaster and Assessing Resource Needs

Once the ancillary services director decides that the MEICS event is significant enough that the Department of Laboratory Medicine and Pathology (DLMP) will be affected, the ancillary services director will contact the laboratory unit leader and ask that the DLMP MEICS plan be activated. Action sheets were developed to assist the laboratory unit leader in documenting that key actions have taken place—those related to communications, establishing a chain of command, establishing a command center, and determining a variety of resource needs. These resources include, but are not limited to, the need for blood, transportation, inventories of critical supplies and materials, personnel, schedules, food, lodging, and types of laboratory services that will be most needed. The activities and resource need assessments listed on the action sheets are prioritized into immediate, intermediate, and extended categories. The immediate actions include these:
1. Activating the calling tree and documenting who was contacted for each tier
2. Establishing a DLMP command center (choose from 3 previously established sites that are stocked with emergency supplies, forms, and the red vest)
3. Donning the red vest
4. Establishing secretarial (scribe) support to do the following:
   a. Begin a journal of activities on a DLMP MEICS Log form
   b. Document needs, concerns, and decisions made
   c. Operate the tape recorder
   d. Establish a sign-in sheet for all leadership

Fig. 3. MEICS Calling Tree (names and phone numbers removed)
A summary diagram of the MEICS calling tree form that the laboratory unit leader uses to contact the operations managers once the ancillary services director has determined that laboratory services will be needed as part of the MEICS disaster response. Operations managers can then, in turn, contact their respective divisional medical directors and operations administrators. The MEICS calling tree allows laboratory response personnel to be contacted in a tiered fashion based on likelihood of need. This minimizes unnecessary responders placing undue burden on the response plan infrastructure and resources. In case response personnel cannot be contacted, the calling tree also provides a pool of alternative contacts. The calling tree serves as a centralized source for up-to-date contact information for response personnel and is accessible via the Mayo Clinic telephone operator. The calling tree and entire MEICS plan are reviewed and updated quarterly.
reporting to the command center including, but not limited to, operations managers, divisional medical directors, and operations administrators.

5. Reporting to the ancillary services director on the following:
   a. Blood inventory needs
   b. Critical equipment and supplies inventory needs
   c. Availability of laboratory staff (labor pool)

6. Interacting with divisional laboratories and services to do these:
   a. Communicate laboratory-specific needs
   b. Relay information to laboratories
   c. Establish frequency, time, and location of briefing meetings

The intermediate actions include these:

1. Identifying whether phlebotomy services are needed
2. Identifying whether pneumatic transport tube system is available
3. Determining whether point-of-care testing is needed and if so doing these:
   a. Determine the type of testing needed
   b. Identify teams to travel to testing locations
4. Delegating human resources, communications, and transportation

The extended actions include these:

1. Establishing relief for leaders
2. Developing a schedule for rotation of leadership
3. Contacting the ancillary services director if any of these apply:
   a. Additional personnel are needed for staffing
   b. Family support is needed for staff
   c. Lodging is needed for staff
   d. Food and water are needed for staff

A second action sheet is used to capture information related to the emergent situation. Using this form the laboratory unit leader can capture this information:

1. Leader's name, for reference by other leaders
2. Nature and magnitude of the incident, including the expected number of patients
3. Expected duration of the incident
4. Location of the incident
5. Location of the Mayo Clinic command center
6. Name and contact number of the person who notified the laboratory unit leader of the emergent situation
7. Date of the emergent situation
8. Expected laboratory services needed
9. Location of the DLMP command center
10. Time the calling tree was activated
11. Assessment of the blood inventory
12. Assessment of any other laboratory services needed
13. Any other pertinent notes

Specific Laboratory Actions and SOPs

The final portion of developing the overall MEICS plan was to establish laboratory-specific action items that could be written into standard operating procedures (SOPs) for each laboratory throughout the DLMP for reference by laboratory personnel. In Transfusion Medicine we decided to incorporate the specific action items for MEICS activation into our already existing disaster plan procedure. Much like the developers of the departmental plan, we developed an evaluation checklist for the operations managers to use to assess the emergency, record decisions, define the location of the command center, and capture relevant contact information. The disaster evaluation checklist helps the operations manager capture the following:

1. Evaluation of the need for additional personnel in each work unit
2. Notification of outside blood donation testing laboratories and sample testing transportation providers
3. Evaluation of the need for external source of blood if a large supply of blood components is anticipated, computers are not functioning, or both. If the external source does not have an adequate supply, inquire about the possibility of them establishing a mobile site locally until Transfusion Medicine can resume collections
4. Determination of whether blood collection, transfusion, and processing should be discontinued for these:
   a. Therapeutic apheresis procedures (consider the need to disconnect piped-in oxygen)
b. Donor services (blood collection), including fixed and mobile sites

c. Intraoperative autotransfusion services, listing which hospital locations

5. Relocation of specific work units, if required, and the new locations

6. Relocation of blood inventory, and to where, with a specific list of locations that have the capability for large, monitored, refrigerated storage capacity

7. Any additional supplies that are needed: amount, source, date of receipt, lot number, and manufacturer

8. Determination of whether or not a blood shortage will occur and, if so, the upward communication from the Transfusion Medicine chair to the MEICS Blood Rationing Team

Transfusion Medicine Communication Planning

A Transfusion Medicine calling tree was developed to ensure timely notification of key response personnel. However, unlike the DLMP MEICS calling tree, which uses a tiered approach, the Transfusion Medicine calling tree uses a time requirement notification approach, indicating key contacts that should occur within the first 30 minutes, first hour, first 2 hours, and first 4 hours, as shown in Figure 4. We developed the time requirement approach to organizing our response plans in Transfusion Medicine to help us ensure that key decisions can be made about the potential for blood shortages. Communication about the potential for blood shortages needs to flow back to the MEICS command personnel and the Blood Rationing Team so that timely decisions can be made about how the remaining blood supply should be used. Likewise, decisions about public communication concerning the blood shortage must be made.

The Blood Rationing Team

To adequately respond to the need for blood or blood components subsequent to a natural disaster, terrorism, or internal crisis, a Blood Rationing Team was developed under MEICS. Within the MEICS organizational structure, the team reports to the medical staff chief. The development of a prescriptive blood rationing plan was not feasible because not all circumstances could be anticipated. The
Blood Rationing Team, consisting of internal experts, quickly assesses threats to the blood or blood component supply; decides how quickly and completely the blood inventory can be “recovered” to adequate levels; and proposes solutions to limit or avoid a crisis that causes, or threatens to cause, inadequate patient care. When activated, the Blood Rationing Team weighs the demands for blood or blood components against the inventory. The Blood Rationing Team triages demands and makes decisions to limit transfusions and elective surgical procedures as necessary. The Blood Rationing Team consists of chairs of each of the following: Transfusion Committee, Cardiac Surgery, Clinical Practice Committee, Ethics Committee, Hospital Practice Committee, Surgical Committee, Transfusion Medicine, Bone Marrow Transplantation, and Liver Transplantation. The Emergency Blood Rationing Team is activated any time the chair of the Division of Transfusion Medicine (or designee) determines that the supply of blood or blood components is sufficiently low to threaten the ability to meet patient needs. The chair of the Division of Transfusion Medicine (or designee) activates the Blood Rationing Team by requesting that the telephone operator notify team members of an emergency meeting, including time and location. The MEICS incident commander (or administrator on call) is also notified.

Transfusion Medicine Flowcharts and SOPs

Flowcharts for each work unit within Transfusion Medicine were also developed to reflect key steps in...
the disaster plan SOP. As in the calling tree, a time requirement approach was used to organize the key response steps in the flowcharts and to help identify in the early stages of the disaster any potential for blood shortages or the need to discontinue or increase blood collections or services. In addition, the time requirement approach used in the flowcharts and disaster plan procedure allows us to identify within the first hour of a disaster the need to contact our outside blood suppliers for additional support, the need to relocate laboratories and personnel, the need to call in additional personnel, and the possible need to activate the AABB disaster plan.5

Discussion

At the 2007 AABB annual meeting workshop on disaster planning, participants learned about the importance of planning for disaster management to maintain continuity of operations in various emergency and disaster-related events. Various speakers emphasized how most disasters are “managed at the local level.” Organizations conducting disaster planning exercises need to develop interfaces and understand how they will interact with emergency responders at the local, state, and national levels when responding to the cycle of disaster management.6

With proper planning and consideration of the key factors important in managing the various aspects of disasters, organizations can mitigate untoward consequences that can prevent them from continuing vital operations such as maintaining a readily available blood supply. We have been able to successfully develop a MEICS plan with several key features. These include coordination with national and local response plans, generic flexibility to deal with multiple scenarios, an established chain of command, a list of key response personnel and their responsibilities, a process for contacting key response personnel using a calling tree, defined roles during a MEICS activation for each laboratory—including Transfusion Medicine—and action sheets to assist in resource analysis and decision making. A high-level summary diagram of how the specific pieces of the plan flow together to form a disaster response is provided in Figure 5 to illustrate how information, communication, and some key actions might be handled, especially within Transfusion Medicine. Although the disaster response plan described here is specific to Mayo Clinic, the general key concepts, processes, and considerations of disaster planning, especially Transfusion Medicine response planning, can be applied by almost all major health care institutions.

Subsequent to the drafting of this manuscript, Mayo Clinic Rochester has adopted the National Incident Management System (NIMS) under the Hospital Incident Command System (HICS).7 This has had no effect on the plans that have been described in this manuscript. Mayo Clinic Rochester had previously been working towards NIMS compliance under the directives and guidance set forth by the Federal Emergency Management Agency in September 2006 as described in the NIMS Implementation Activities for Hospitals and Healthcare Systems document.

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A moving experience: lessons learned from relocating a reference laboratory

D. Long

Since 1965, the American Red Cross Southern Region headquarters has been located in a 60,000 square foot building in the heart of Midtown Atlanta (Fig. 1). As the years passed, the region experienced growth not only in collections but also in the size of its infrastructure. The mounting regulatory requirement of the 1990s contributed significantly to this escalation. Insufficient space began to limit opportunities for further growth and process improvements. In an effort to ease the space constraints, several expansions and major renovations occurred during this period. It eventually became necessary to decentralize the headquarters facility by using several offcampus annexes. In other words, the blood center was rapidly outgrowing its facility.

The business decision to consolidate Southeast Division (to include Georgia, Alabama, and North and South Carolina) manufacturing within the Southern Region left no doubt that a new facility, purposely designed for the manufacturing of blood and blood components, was needed. The Midtown location simply could not accommodate the required increase in throughput, slated to approach one million units annually. The request to build a new 180,000 square foot blood processing center (BPC) in Douglasville, Georgia, was approved by American Red Cross National Headquarters in May 2002 (Fig. 2).

Excitement grew with the recognition of the opportunities ahead—most notably the chance to contribute to the design of a state-of-the-art reference...
lab! This new facility would be designed to meet the specific operational requirements of the laboratory, a distinct departure from our past experience of adjusting processes to conform to existing spaces.

The initial enthusiasm gradually waned over the next few months as the magnitude of the job that lay ahead was realized. When Ross Perot made a late entry into the 1992 presidential race, he remarked that the scrambling required to organize his campaign was “like building an airplane in mid-flight.” Moving an immunohematology reference laboratory (IRL) of this size and complexity a distance of 29 miles posed a similar problem. The luxury of a pause in operations to accommodate the move did not exist. To continue the analogy, “landing” was not an option. This article is devoted to providing the reader (perhaps one charged with the same task) with a few “lessons” that were learned during one adventure in IRL relocation.

Key Considerations

The wheels of the planning process should start turning the day after the decision to move is made. While that is a bit of an overstatement, there is a tremendous amount of work ahead and the planning process has to be managed as a top priority. Together, effective planning and communication will be the linchpin of a successful move. Take this initial period to review the organization’s strategic goals and objectives to ensure that the logic applied in the planning process is sound and consistent with the organization’s mission. Give careful consideration to which essential laboratory functions must be included in the new operation, in both the short and the long term (Refer to Table 1 for a list of available resources for use in moving an immunohematology reference laboratory). Getting the development process off and running will require a concerted effort and involvement of the entire laboratory staff. This is definitely a team effort.

Once constructed, the initial planning documents will lay the groundwork for the planning process. These living documents should reflect every activity that will likely occur in the new space, however extensive or minor. There will be opportunities to review and revise the plan during the development phase. Bear in mind that revisions made after construction has begun are extremely costly. Remember that a laboratory scientist is not a master builder or planner; the support and guidance of a team of professionals will ensure success. Identify a laboratory consultant with a thorough knowledge of the laboratory operations to work closely with the architects and builders throughout the life of the project. While the facility is being constructed, develop a detailed transition and move-in plan. These should include a timetable for equipment setup, qualification, and requalification. The transition plan starts shortly before the move and ends with the decommissioning of the current facility (Fig. 3). The transition plan addresses how operations in the current facility will be maintained while bringing the new facility on line. Much like focusing a microscope, the planning process should progress by a level of detail with each

Table 1. Resources for moving an immunohematology reference laboratory

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| Jacobson JM, Johnson ME. Lean and Six Sigma; not for amateurs (part 2). LabMedicine 2006;37:140-5. |
successive stage. The entire IRL relocation process might be divided into five major phases:

- **Phase I:** Establishing the location of the IRL within the new facility
- **Phase II:** Designing the IRL
- **Phase III:** Planning the move
- **Phase IV:** Executing the move
- **Phase V:** Finalizing the move

Key considerations for each of the five phases of the move are highlighted below.

**Phase I: Establishing the location of the IRL within the new facility:**
- Work with other department heads to develop facility incoming and outgoing process flows to identify inputs, outputs, and required IRL adjacencies (e.g., storage and distribution, irradiation, liquid and frozen red cell inventory locations, and bio-waste).
- Plan placement of liquid nitrogen delivery systems. Consider the proximity of the IRL to the exterior walls if piping of liquid nitrogen is planned. If liquid nitrogen tanks will be used, consider proximity to delivery bays as well as delivery pathways.
- Consider the communication and logistical challenges of a larger physical space and evaluate the need for mitigation strategies (e.g., robotic sample delivery system).
- Determine whether laboratory space will include or exclude administrative space and meeting areas.

**Phase II: Designing the IRL:**
- Prepare a flow analysis (spaghetti diagram) for each key IRL process. Design the layout to facilitate maximum efficiency and efficacy of processes and eliminate physical barriers.
- Consider all staffing patterns in the work flow analysis. Staffing levels often vary between shifts (i.e., 18 staff may work on day shift while only 2 staff work on night shift). A work flow designed solely around day shift patterns may not be functional for night shift.
- Apply Lean principles wherever possible. The goals of Lean are to improve quality, eliminate waste, reduce lead time, and reduce total cost.
- Be aware that a poorly designed lab can be disruptive to quality and service delivery.
- Focus on the number, size, location, and specific work functions and support activities that need to be included in the design and co-locate similar processes wherever possible.
- Network with other IRLs to get ideas. Visit new or recently renovated IRLs whenever possible.
- In general, plan for more space than will be needed, to allow for future growth.
- Bear in mind that flexibility is an important consideration in designing the work spaces. Adjustable casework that can be reconfigured makes it possible to redesign work spaces to meet future needs.
- Define any special requirements for work spaces (e.g., air handling in areas with heat-generating lab equipment that could impact the ability to regulate the temperature to keep it within requirements).
- Select new lab furnishings and surfaces that are compliant with the regulations of the Occupational Safety and Health Administration.
- Ensure that utilities (e.g., power supply, data ports, and drainage) are sufficient in number and location to allow flexibility in placement of instruments and equipment.
- Plan for additional cooling capacity in areas with heat-generating equipment (e.g., ultra low freezers).
- Provide adequate lighting, especially immediately adjacent to the work station, as well as emergency power.
- Include space for automated equipment in the floor plan. Even if automation is not currently part of the laboratory, it likely will be.
- Consider floor drains or other means for direct disposal of cell washer waste liquids, if allowed by local code.
- Include space for record storage, both hands-on and temporary storage.
- Consider creating a designated review area. Locate the review room away from work stations and the flow of foot traffic. Include a door to reduce noise, distraction, and the potential for interruption. This area should be telephone free. Include a small, monitored refrigerator for temporary product storage, if possible.
- Consider creating a reagent preparation area.
- Consider a separate room or area for frozen reagent RBC storage.
Lessons learned from relocating an IRL

• Consider creating a customer communications area, equipped with telephone, computer, and reference resources.
• Once the new facility plan has been established, it will be critical to continually evaluate all subsequent organizational and operational changes against it.
• Confirm understanding of all changes in the final building plans in writing. Include all affected department heads, move leads, and the architect among the recipients.
• Develop a prototype of the proposed IRL floor plan and share it with IRL staff for input.
• Don a hard hat and access the building during construction as frequently as possible, to avoid surprises.

Phase III: Planning the move

• Designate one senior move coordinator for the entire facility project, to serve as the central point of contact and clearinghouse for all communications, planning, and changes.
• Designate for each functional area a move lead and a planning team, made up of a cross section of departmental staff. Include a quality assurance representative with previous IRL experience on the team, if possible.
• Determine contingencies for sequencing the phased move plan (e.g., the entire storage and distribution function cannot be scheduled to move before the reference laboratory moves).
• If possible, be selective about the time of year of the move. Spring was selected for the move to Douglasville, to avoid the extreme weather conditions of the summer or winter months.
• Consider contracting with a specialized company (e.g., Pacific Scientific Transport) for moving rare reagent droplet RBC and rare frozen RBC inventories. While outsourcing this activity can be somewhat costly, minimizing the risk of losing these critical—and in some cases irreplaceable—resources is worth the expenditure.
• Contract with a moving company with a proven track record. A systematic approach to labeling moving boxes and crates is critical.
• Develop a plan to move temperature-sensitive reagents and supplies.
• Use this opportunity to reorganize and “clean house.” Consider holding regularly scheduled “purge days” in the months leading up to the move. Encourage staff to discard materials (equipment, nonregulated documents, etc.) that are not being taken to the new facility.
• Discourage reordering large quantities of envelopes, letterhead, business cards, etc. with the address of the old facility. Remember to reorder these items once the new address is known.
• Establish a document control plan. At a minimum, most regulated documents require an address change. Avoid changes in formatting during this process, since the addition of lines could impact pagination.
• Working with equipment and quality staff, establish a process for the systematic execution and approval of qualification and requalification plans during the transition to the new facility.
• Involve staff in the move planning—develop teams to help with identified parts of the pre-move, move, and post-move.

Communication Plan

• Hold regularly scheduled functional area move team meetings and cross-functional meetings with move leads and department heads. This dialogue will be critical as transition and move plans evolve over time.
• Meet with hospital customers who will be impacted by the move to hear their concerns. Develop and communicate the resulting mitigation strategies.
• Communicate with hospital customers regularly. Include move dates, move plan details, new phone system information, changes in delivery routes and times, and temporary contact information for use during the move.
• Consider providing cards or magnets with new telephone numbers to hospital customers. Their comfort level with the move will increase with regular, positive communication.
• Review all existing service contracts. Communicate with vendors about changes in terms caused by the relocation. Ensure that they have the new facility address and know when to begin shipping supplies or reagents to the new location.
• Provide written communication of the new address to all contract customers (e.g., those with transfusion service agreements).
• Communicate with IRL staff frequently. The need to do this cannot be stressed enough. Monthly updates at staff meetings, open houses,
information to assist staff with housing reloca-
tion, and transportation information are just a
few items to consider.
• Use multimedia reminders. As move time ap-
proaches include a standard footer note for
inclusion in all fax and e-mail communications,
announcing the upcoming move and contact
information. Recorded voice mail messages
can also be used to provide brief reminders to
callers.

Staffing Plan
• Technical staff will have their hands full keep-
ing up with testing during the move. Ensure
that they have adequate resources for packing,
unpacking, cleaning, decontaminating surfaces,
and answering the telephone.
• Hire nontechnical temporary staff 2 to 3 months
before the move to allow time for training and
familiarization.
• Work with reliable temporary staffing agencies.
Last-minute resignations of trained temporary
staff can be problematic.
• Consider planning for split operations during
the move. The transition of the IRL from the
Midtown location to the Douglasville BPC oc-
curred over a 3-week period, with an increasing
number of staff working from the new facility
during each phase.

Phase IV: Executing the move
• Designate key staff (equipped with cell phones)
to serve as points of contact at each facility
while the move is in progress.
• Ensure that cell phone coverage will be enabled
in the new facility. This is critical for communi-
cating during the move until the new facility’s
phone system is activated.
• Review the list of items to be moved before the
actual move to prevent delay when the movers
arrive.
• Place signs on equipment, supplies, etc., be-
ing moved, indicating the exact room number
at the new facility to which they are to be
delivered. Place signs marking the exact loca-
tions for placement of each item in the new
facility.
• Ensure there is continued support of the old
facility until the move is complete (e.g., tele-
phone, trash removal, rest room maintenance,
and vending machine supplies).

Phase V: Finalizing the move
• Temporary nontechnical staff can be used to
decontaminate equipment and surfaces during
the decommissioning of the old facility.
• Ensure that all telephones at the old facility are
forwarded to voice mail messages that provide
the new telephone numbers at the new facility.
These voice mail messages should remain avail-
able for several weeks after the move.
• Plan a grand opening event for the new facility.
The event should be scheduled at least 6 weeks
after the move, to allow time for unpacking and
completion of punch list items. Be sure to invite
local media, local officials, hospital customers,
financial contributors, and blood donors.

The information presented in this article is not
intended to be an all-inclusive checklist for executing
a move. It essentially represents a compilation of
“lessons learned.” Undoubtedly there will be many
unique aspects to the circumstances surrounding the
“moving experience,” but hopefully a few of these
key considerations will be of direct value and others
may serve as springboards for further discussions
with the move team.

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RBC components with rare phenotypes are sometimes required for patients with sickle cell disease, and these rare components can often be found among donors with sickle cell trait. Cryopreserving RBC components from sickle cell trait donors requires a modified deglycerolization method to preserve the integrity of the RBCs. This study evaluated the feasibility of using an automated cell-processing system to cryopreserve and deglycerolize sickle cell trait donor RBC components. CP2D/AS-3 RBC components were collected from three donors with sickle cell trait. Each component was processed with an automated cell-processing system (ACP 215, Haemonetics Corp., Braintree, MA) and cryopreserved within 6 days of collection. The components were stored at −65°C or less for at least 2 days and were deglycerolized using the automated cell-processing system's standard procedure. Before cryopreservation and after deglycerolization, several variables were measured. Deglycerolization resulted in recovery of 43.0, 76.5, and 67.5 percent of RBCs from the three sickle-cell-trait donor components compared with 80 percent or greater for all six control components. A small, dark red, jelly-like mass was noted in the bowl of the disposable set after deglycerolization of each of the three RBC sickle cell trait components. The osmolalities of all three sickle cell trait components were less than 400 mOsm/kg, but only one of the three was acceptable for a 14-day outdate. Freezing and deglycerolization of sickle cell trait donor RBC components with the automated cell-processing system resulted in recovery of some RBCs, but a decrease in RBC recovery was problematic. Modifications of the procedure are needed for processing sickle cell trait donor RBC components. Immunohematology 2008;24:107–111.

Key Words: glycerolization, deglycerolization, sickle cell trait, cryopreservation

Patients with sickle cell disease (SCD) often require RBC transfusions throughout their lifetimes. These patients are exposed to blood from multiple donors and have an increased chance of forming alloantibodies. According to one study, transfused patients with SCD have up to a 29 percent chance of becoming alloimmunized.1 This immunization occurs because the majority of RBC transfusions are obtained from Caucasian donors and subsequently result in exposure to major differences in antigens.2

Because of the differing hospital protocols concerning the matching of RBC blood group phenotypes of patients with SCD and RBC component donors, these patients may receive RBC components that have only been matched for ABO and D blood group antigens. Osby and Shulman3 report results of a survey that indicate 62.9 percent of hospitals crossmatch only ABO/D-compatible blood whereas 27.9 percent determine the patient’s baseline phenotype for commonly immunogenic antigens and crossmatch ABO/D-compatible and phenotypically matched RBC units. Alternatively, 9.2 percent of hospitals report that the patient’s baseline phenotype for common antigens is determined, but crossmatch only ABO/D-compatible RBC units initially.3 After an antibody is made, all subsequent RBC units transfused are antigen matched. Initiation of transfusion of phenotypically matched RBC units only after immunization occurs is based on the observation that some patients develop alloantibodies after relatively few RBC transfusions and are referred to as "responders" whereas others may be "nonresponders" who may not make antibodies even after multiple
transfusions with RBCs matched only for ABO and D blood group antigens.\(^1\)

The risk of alloimmunization of patients with SCD may make it difficult to find phenotypically compatible RBC components for transfusion. Some patients need RBC components from donors with unusual phenotypes that can only be found in repositories of cryopreserved RBC components with rare phenotypes. The probability of finding compatible components for patients with SCD is higher among donors who are African or of African descent, who are more likely to have similar RBC phenotypes.\(^4\)

Blood donors who are likely to have RBCs phenotypically compatible with those of patients with SCD are also at risk to be heterozygous for the gene encoding hemoglobin S (HbS) and thus be HbS/HbA. The donor population that expresses heterozygosity for the gene encoding HbS has sickle cell trait, but is healthy. However, collecting and preparing RBC components from donors with sickle cell trait presents two difficulties. The first is filter failure, which can be defined as the inability to remove a sufficient number of leukocytes, and the second is the clotting of the blood inside the filter. Neither of these outcomes is inevitable, but one study found that approximately half of the RBC components collected from people with sickle trait occlude WBC-reduction filters, one quarter pass completely through the filter but the quantity of WBCs remaining exceeds criteria for WBC reduction, and only one quarter are effectively filtered.\(^5\) Polymerization of HbS during the collection and processing of the blood is responsible for the occlusion of leukocyte-reduction filters, but this problem can be reduced by the collection of RBC components by apheresis.\(^6\)

The second problem is RBC cryopreservation. Unless a modified method described by Meryman and Hornblower\(^7\) is used, the deglycerolization process exposes RBCs to hyperosmotic saline, which produces extreme hemolysis of sickle cell trait donor RBCs and yields a dark red, jelly-like mass rather than a suspension of RBCs. The standard deglycerolization procedure used with a semiautomatic cell washer involves dilution of the thawed cells with 12% saline followed by dilution with 1.6% saline and washing with 0.8% saline plus 0.2% glucose.\(^8\) The modified procedure involves dilution of the thawed cells in 12% saline followed by dilution in a large volume of 0.8% saline plus 0.2% glucose followed by washing in 0.8% saline plus 0.2% glucose.\(^7\)

The Meryman and Hornblower method\(^7\), however, was described for use with traditional processing, which involves an open system. When an open system is used, once the RBC components are thawed and deglycerolated, they expire within 24 hours. This short shelf-life can result in the loss of RBC components with rare phenotypes if they are unable to be transfused within 24 hours. However, allowances do exist to refreeze rare donor units one time.\(^2\)

Recently, the FDA has approved an automated blood processing system, ACP 215, to freeze and deglycerolize RBC components.\(^9,10\) This instrument is a functionally closed system conferring a 14-day outdate on the component. In addition, deglycerolization of RBCs with the automated blood-processing system involves dilution in 12% saline and washings in 0.9% saline plus 0.2% glucose.\(^9,10\) Inasmuch as these deglycerolization solutions were similar to those described by Meryman and Hornblower,\(^7\) we hypothesized that the ACP 215 may allow for the successful deglycerolization of sickle cell trait donor RBC components. This study assessed the feasibility of using the ACP 215 for the cryopreservation and deglycerolization of RBC components from donors with sickle cell trait.

**Materials and Methods**

**Study Design**

Donors with sickle cell trait were recruited from a population of healthy people who regularly donate blood for research studies at our institution, and informed consent was obtained before the blood was collected. Whole blood units were collected and processed into nonleukoreduced RBC components from three donors with sickle cell trait, and each component was processed with an automated cell-processing system (ACP 215, Haemonetics Corp., Braintree, MA) and cryopreserved within 6 days of collection. Although the ACP 215 is not approved for processing CP2D/AS-3 nonleukoreduced RBCs, leukoreduction was not performed in this study to avoid filter failure and loss of sickle trait units. The components were stored at –65°C or less for at least 2 days and were deglycerolized using the ACP 215's standard procedure. Before cryopreservation and after deglycerolization, several variables were measured including weight, hematocrit, and supernatant hemoglobin levels. Data from RBC components collected from six healthy routine blood donors without
sickle cell trait were collected and used as controls. These control units were cryopreserved, thawed, and deglycerolized using the same automated cell-processing system. All the donors met the AABB criteria for donating whole blood. The study was approved by the institutional review board.

**Study Population**

Blood from three donors with sickle cell trait was studied. Donor 1 was a 23-year-old woman with a mixed ethnic background. Donor 2 was a 59-year-old Black woman. Donor 3 was a 37-year-old Black woman. The control units were collected from healthy donors ranging from 50 to 61 years of age. Four of the control donors were men and two were women. All were Caucasian.

**Collection and Processing of RBC Units**

A unit of whole blood was collected using a standard collection method for whole blood drawn into a CP2D/AS-3 triple blood bag set with an in-line filter and Y sampling site (Pall Corporation, East Hill, NY). Within 4 hours of collection, the whole blood was spun down and plasma was expressed off the unit.

The in-line leukocyte filter was then removed using a heat sealer (Composeal Mobilea, Fresenius HemoCare, Redmond, WA), and the tubing was re-joined to the bag containing the AS-3 using a sterile connecting device (SCD sterile tubing welder, Terumo Medical Corporation, Somerset, NJ). Next, the AS-3 was added to the packed RBCs without leukocyte filtration. The RBC component was then refrigerated at 1° to 6°C for at least 2 days before freezing.

**Cryopreservation**

The AS-3 RBC components were centrifuged and the supernatant removed. The units were then steriley connected to the ACP 215 standard disposable glycerolization kit (Haemonetics REF 225, ACP 215 Red Cells Glycerolization Disposable Set, Haemonetics Corp.), and were glycerolized automatically by the ACP 215 according to manufacturer's procedure. Once glycerolized, the units were centrifuged and excess glycerol was expressed off. The components were heat sealed in a polyester plastic bag to maintain sterility and were frozen. The units were stored for at least 2 days at –65°C or less before deglycerolizing. A more comprehensive description of the process using the ACP 215 can be found in a study by Valeri et al.9,10

**Deglycerolization**

The units were removed from the freezer and placed into a 37°C water bath until they reached a temperature of 32° ± 2°C. Using the ACP 215 disposable deglycerolization set (Haemonetics REF 235, ACP 215 Red Cells De-Glycerolization and Cell Wash Disposable Set, Haemonetics Corp.), the components were deglycerolized first with 12% saline followed by multiple large-volume washes using 0.9% saline containing 0.2% glucose. After washing was complete, the final product was resuspended in AS-3. In-process pressure checks at the end of deglycerolization indicated that the system remained closed and the units could retain a 14-day outdate. As an additional indication of acceptability, a visual hemolysis check was performed on the waste supernatant using a color chart provided with the ACP 215 to ensure the free hemoglobin levels were less than 150 mg/dL. A sample was taken for analysis of several variables including analysis of the wash supernatant for plasma hemoglobin and osmolality.

**Laboratory Analysis**

At the time of the collection of the unit of whole blood, an additional tube of blood was drawn into EDTA for HbS analysis. HbS was analyzed using ion-exchange high-performance liquid chromatography (Varian HPLC system, Bio-Rad Diagnostics Group, Hercules, CA).

Before cryopreservation and after deglycerolization of the RBC component, samples were taken for laboratory analysis and components were weighed for the calculation of the percent recovery of RBCs. The

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Fig. 1. A dark red, jelly-like mass in the bowl after deglycerolization.
blood sample was used to test the hematocrit using a microhematocrit system (HemataStat II, Separation Technologies, Inc., Altamonte Springs, FL). Plasma hemoglobin levels were also analyzed with a low-Hb photometer (HemoCue AB, Angelholm, Sweden). An iSTAT (i-STAT Corporation, East Windsor, NJ) was used for measurement of blood gas analytes.

In addition, samples of the wash supernatant were analyzed for osmolality to ensure adequate removal of the glycerol. Osmolality was performed using the method of freezing point depression on a microsample osmometer (Fiske 2400, Advanced Instruments Inc., Norwood, MA).

**Statistics**

Because of the relatively small sample size (n = 3), statistical analysis was not performed as significance could not be determined.

**Results**

Thawing and deglycerolization of all three RBC components from the donors with sickle cell trait resulted in the recovery of some RBCs (Table 1); however, the plasma hemoglobin level on the postdeglycerolization supernatant sample from Donor 1 was extremely high. All components had acceptable osmolality levels of less than 400 mOsm/kg, indicating that glycerol removal was adequate. Only the RBC component from Donor 2 passed the in-process pressure check indicating that the system remained closed during processing, conferring a 14-day outdate. A dark red, jelly-like mass was noted in the bowl after deglycerolization of all three components and was the largest for the component from Donor 1 (Fig. 1).

The hematocrit levels of the deglycerolized components ranged from 26 to 47 percent, and the RBC recoveries ranged from 43 to 76 percent. The donors’ HbS levels ranged from 34 to 39 percent. There appeared to be no relationship between RBC recovery and the donors’ HbS levels (Table 1). As expected, glucose and potassium levels in the RBC components decreased after deglycerolization and sodium levels increased (Table 2). Washing removes approximately 99 percent of plasma proteins, electrolytes, and antibodies and exchanges residual CP2D for residual 0.9% saline with 0.2% glucose. In comparison, all six control RBC components collected from donors without sickle cell trait had a postdeglycerolization RBC recovery of 80 percent or greater, an osmolality of less than 400 mOsm/kg, and hematocrit levels of 49 percent or greater (Table 3). Glucose, potassium, and sodium were not measured on the control units.

The sickle cell trait donors’ RBC components were all frozen 4 or 5 days after their collection and were stored for 4, 35, and 56 days before deglycerolization. RBCs from Donor 1 were cryopreserved the longest followed by Donors 2 and 3. Future studies using the ACP 215 are needed to conclude whether there is a relationship between storage time and percent recovery after deglycerolization.
Discussion

An automated cell-processing system, APC 215, is available for the freezing and deglycerolization of RBC components and is being used to save rare donor units. We tested this system using the manufacturer's recommended procedures to process RBC components from donors with sickle cell trait to assess the feasibility of obtaining an acceptable cryopreserved and deglycerolized RBC component for transfusion. RBC components from all three donors tested resulted in recovery of some RBCs. However, none of the deglycerolized components met the criteria for greater than 80 percent recovery of RBCs, and congealed RBCs were noted in the bowl after the processing of each of the three components. The process resulted in components that had osmolality levels that indicated the units were successfully deglycerolized, but it is not certain whether the posttransfusion recovery and survival of these components would be normal.

The mean of RBC recovery for our study was 62 percent compared to 56 percent by Meryman and Hornblower\(^7\) using the traditional deglycerolization method and a manual cell washer. The RBC recovery with the APC 215, however, was not as good as with the modified method for processing sickle cell trait donor RBC components described by Meryman and Hornblower\(^7\); mean recovery was 85 percent. We do not recommend that the standard APC 215 cryopreservation and deglycerolization methods be used for the routine processing of sickle cell trait donor RBCs, but it may be possible to modify the deglycerolization procedures used with the APC 215 method to improve the recovery of sickle cell trait RBCs. Because hemolysis of sickle cell trait donor RBCs occurs in the deglycerolization process,\(^7\) modification of the APC 215 deglycerolization solution may improve RBC recovery. Perhaps greater dilution of the thawed RBCs with the solution containing 0.9% saline plus 0.2% glucose or increasing the pH of the deglycerolizing solutions\(^11\) would reduce hemolysis. Minimizing osmotic damage during glycerolization by adding glycerol more gradually through the use of additional steps may also be helpful.\(^12\)

In conclusion, freezing and deglycerolization of sickle cell trait donor RBC components with the APC 215 system resulted in better recovery than did the manual method, but it was not better than that produced by the modified method by Meryman and Hornblower.\(^7\) However, hemolysis and agglutination in the bowl were problematic. Future modifications of the deglycerolization procedure using the APC 215 are needed for successful processing of sickle cell donor RBC components.

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Overt immediate hemolytic transfusion reaction attributable to anti-Wr\textsuperscript{a}

F.N. Doctor

Wr\textsuperscript{a} is a low-prevalence antigen. Anti-Wr\textsuperscript{a} is a relatively common antibody present in approximately 1 in 100 healthy blood donors. Anti-Wr\textsuperscript{a} is reported to cause different degrees of hemolysis in transfusion and in HDN, ranging from benign to severe. This report describes an acute overt hemolytic transfusion reaction in a patient whose serum contained anti-Wr\textsuperscript{a} and who received a Wr(a+) RBC component.

Key Words: low-prevalence antigens, Wr\textsuperscript{a}, anti-Wr\textsuperscript{a}, hemolytic transfusion reaction

In 1953, Holman\textsuperscript{1} described an RBC antibody, which was named anti-Wr\textsuperscript{a}, that detects a rare antigen, Wr\textsuperscript{a}. In 1995, Wr\textsuperscript{a} was shown to be part of the Diego system,\textsuperscript{2} which is controlled by the SLC4A1 (DI)\textsuperscript{3} gene on chromosome 17. The prevalence of Wr\textsuperscript{a} is 1 in 1000 in the White British population\textsuperscript{4} and 1 in 785 in the White Spanish population.\textsuperscript{5} Although far fewer people have been tested, Wr\textsuperscript{a} has not been found in Blacks, Australian Aborigines, natives of New Guinea, or other non-European populations.\textsuperscript{2} Wr\textsuperscript{a} antigens on RBCs are resistant to treatment with proteolytic enzymes, including trypsin, \( \alpha \)-chymotrypsin, papain, and pronase, or neuraminidase and to treatment with 2-aminoethylisothiouronium bromide.\textsuperscript{2}

Anti-Wr\textsuperscript{a} is a relatively common antibody with an incidence of 1.06 to 4.3 percent in the sera of healthy individuals and is more frequent (4 to 10%) in patients with autoimmune hemolytic anemia and in pregnant and recently postpartum women.\textsuperscript{4,5} Anti-Wr\textsuperscript{a} can be isotype IgM reactive at less than 37°C or IgG reactive by IAT. Wr\textsuperscript{a} is well developed in newborns; however, HDN attributable to anti-Wr\textsuperscript{a} is very rare.\textsuperscript{6-8} Although anti-Wr\textsuperscript{a} is common,\textsuperscript{2} it is seldom detected in contemporary antibody-screening tests as Wr(a+) RBCs are not present on commercial reagent screening RBCs.\textsuperscript{9}

The routine use of the immediate spin compatibility test and computer matching of units for patients in whom antibody screening tests are negative may result in some patients with anti-Wr\textsuperscript{a} receiving Wr(a+) RBCs.\textsuperscript{2} However, the probability of incompatibility and hemolytic transfusion reaction is very low. This report describes an acute overt hemolytic transfusion reaction in a transfusion-dependent adult whose serum was nonreactive with reagent screening RBCs and who received a transfusion of Wr(a+) packed RBCs that were compatible at immediate spin. Because of the low probability of a transfusion reaction attributable to the presence of a low-prevalence antigen, an immediate spin or computer crossmatched transfusion can be considered safe.\textsuperscript{10,11} However, if during the transfusion there are any complaints from the patient or changes in vital signs, the transfusion must be terminated immediately.

Case Report

An 83-year-old White man with large granular T-cell lymphoproliferative disorder was diagnosed with aplastic anemia and became transfusion-dependent. The patient received 17 units of packed RBCs during the 3 months before the present episode. The patient had presented for transfusion with Hb of 8.7 g/dL. His RBCs typed as group A, D+; the auto-control and screening tests for unexpected antibodies by IAT were negative. One group A, D+ RBC unit was crossmatched using the immediate spin technique and found to be compatible. During transfusion of the RBC unit, the patient complained of chills and rigors. He received an antipyretic and the transfusion was continued. Posttransfusion hemoglobin was not measured. The patient returned in 2...
days feeling profoundly weak, with a blood pressure of 84/50 mm Hg (pretransfusion blood pressure was 135/86 mm Hg). His Hb had fallen to 7.8 g/dL, his creatinine rose from 2.2 mg/dL before transfusion to 3.3 mg/dL, his LDH level was elevated at 681 IU/L, his total bilirubin was increased from 0.5 mg/dL to 2.3 mg/dL, and his haptoglobin was low normal. Troponin was elevated, which is consistent with a silent myocardial infarction. His DAT was negative and no elution was performed. The ABO group of the transfused unit was reconfirmed, and a serologic workup with panel RBCs was negative. Other possible causes of hemolysis, including medication, were excluded. When IAT crossmatches were performed on the retained donor blood segments with the patient's pre- and posttransfusion serum, both were strongly positive (3+). The specimens were sent to a reference laboratory. The patient received diuretics and also received an IAT crossmatch compatible RBC unit and was discharged on the fourth day of hospitalization.

Material and Methods

ABO and D typing was performed on the patient's samples using standard commercial reagents according to the manufacturer's instructions (Immucor/Gamma, Norcross, GA). The DAT was performed using polyspecific antihuman globulin (Immucor/Gamma) and monospecific anti-IgG and anti-C3d (Immucor, Norcross, GA). Screening for unexpected RBC antibodies was performed by using commercially prepared reagent RBCs (Immucor). The patient's serum was tested against panels of commercial reagent RBCs (Immucor) to determine antibody specificities. BSA and PEG dissolved in a low-ionic-strength medium (PEG, Immucor) were used as enhancing agents. Additional testing to characterize the low-prevalence antibody was performed. Serum was tested against selected RBCs known to possess low-prevalence antigens. LISS and PEG (Immucor, Norcross, GA) were both used. All testing was performed using standard tube tests.

Results

The patient's RBCs typed as group A, D+, and his serum was nonreactive with reagent screening RBCs. The initial immediate spin test was negative. However, when the patient's serum was crossmatched by the IAT with RBCs from the transfused unit, a 3+ reaction was obtained. The DAT on RBCs from the posttransfusion sample was negative. When IAT crossmatches were performed on the retained donor blood segments with the patient's pre- and posttransfusion serum, both were strongly positive (3+). The specimens were sent to a reference laboratory (New York Blood Center, immunohematology laboratory). When the serum was tested against RBCs with low-prevalence antigens, the Wr(a+) RBC samples reacted. No other unexpected antibodies were detected using IAT that included albumin, papain-modified RBCs, and PEG. The Wr typing was performed using single-donor-source antibodies, and the RBCs from the donor unit were Wr(a+).

Discussion

Holman first described anti-Wr as a cause of HDN and named it after the family (Wright) in which it was found. Later the antigen was assigned to the Diego blood group system. Anti-Wr is not uncommon as a naturally occurring or secondary antibody to RBC transfusion or pregnancy. Anti-Wr was found in 7.3 percent of pregnant women and 7.9 to 10.2 percent of hospital patients without other RBC antibodies. Only the rare IgG anti-Wr may cause HDN.

Despite the fact that the antibody could cause hemolysis in vitro, only one case of hemolytic transfusion reaction in an adult patient attributable to anti-Wr was reported and an additional case was described as part of a survey.

In the present case, the antibody screen was negative owing to the lack of Wr on the reagent RBCs. In addition, the immediate spin crossmatch was compatible because of the IgG nature of the circulating antibody. A transfusion reaction was noticed during the RBC transfusion but ignored as a trivial observation. Two days later the patient presented with symptoms and laboratory evidence highly suggestive of a hemolytic transfusion reaction. However, his RBCs did not react in the DAT and an IAT crossmatch of pre- and posttransfusion serum with the remains of the RBC unit showed 3+ incompatibility. The negative DAT may be attributable to the hemolysis of the donor RBCs during the 48 hours after transfusion. The screening for a low-prevalence antigen and antibody showed that the patient has an IgG anti-Wr reactive by the IAT and the donor unit was Wr(a+).

The use of an immediate crossmatch may allow transfusion of incompatible RBCs. Because the
prevalence of Wr\(^a\) is 1 in 1000, the occurrence of the antibody is 7 to 10 percent, and most of the antibody isotype is IgM, the probability of incompatibility and hemolytic transfusion reaction is calculated to be 7 to 10 in 100,000. As a result of this low probability of a transfusion reaction in patients with antibodies directed at low-prevalence antigens, an immediate spin transfusion can be considered safe.\(^9–11\) However, if during the transfusion any complaint from the patient or change of vital signs occurs, the transfusion must be terminated immediately.

Acknowledgments

We thank the staff of the Laboratory of Immunohematology, New York Blood Center, New York, NY, for performing the low-prevalence antigen and antibody testing and Drs. Marion E Reid and Harold H. Harrison for reviewing the manuscript. We also thank Dr. D. Phillips at Sound Shore Medical Center, New Rochelle, NY, and Elisa Steinbacher at Geisinger Medical Laboratory for secretarial assistance.

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Group O red blood cells in massive transfusion—when to pull the switch?

D.N. Moolten

Using uncrossmatched group O RBCs is common practice in the management of patients requiring urgent transfusion. The standard dicta are that one should determine the native patient type as soon as possible and then switch back to that type for further transfusion. Given that group O RBCs contain a quantity of residual plasma and donor isoagglutinins and that the patient’s actual blood type once determined may be other than group O, clinically significant hemolysis (or other immune-mediated sequelae) after such a switch is a natural concern. Hence, most massive transfusion protocols mandate continued use of group O RBCs once a threshold number of units has been given. Unfortunately, the need for such a threshold or even what it should be remains unclear as there are no data contrasting the effects of different thresholds on RBC destruction or survival in the recipient or on patient outcome.

The literature regarding the ill effects of incompatible plasma attributable to RBC transfusion is fairly old and predates the use of additive solutions. Two papers report the safety and efficacy of uncrossmatched group O RBCs in a trauma setting and suggest a threshold number of units. The number of patients receiving massive transfusion was small in each case; the recommendations were made as a result of serologic testing (e.g., higher frequency of a positive antiglobulin test in more heavily transfused patients) and were not outcome based. Given the methods and statistics, this literature is not sufficient to establish either the absolute safety of a lesser number of units or, conversely, the danger of a greater number.

Because no substantiated threshold value exists, practice is necessarily arbitrary. Although no survey regarding such practice has been published, it likely varies considerably. In fact, a perusal of the California Blood Bank Society e-network forum, an electronic discussion board, demonstrates, albeit not rigorously, both this variability and a desire on the part of transfusionists for rational guidance. Fortunately, although data specific to RBC transfusion may be absent, there may in fact be enough evidence available in the literature regarding the effects of incompatible plasma in the setting of platelet transfusion to allow a reasonable, if not conclusive, inference.

A recent review of this literature and survey of practices in 3156 laboratories summarized the available case reports. Brisk hemolysis occurred in a small subset of patients (more often group A) receiving group O platelets; in some cases this hemolysis was associated with a poor clinical outcome. Not surprisingly, pediatric patients appear to be more at risk, and the majority of the reports involve apheresis platelets, in which a significant volume of plasma (approximately 145 to 448 mL, equivalent to the volume of plasma in 5 to 15 additive RBC units) containing a potent high-titer antibody is obtained from the same donor. A study evaluating the changes in hemoglobin in recipients of plasma-incompatible apheresis platelets found no appreciable hemolysis, consistent with the general belief that most patients receiving such components do not routinely suffer adverse effects.

Interestingly, despite these substantial available data, including documentation of in vivo hemolysis in occasional patients, Fung et al. reported quite diverse strategies and policies for adult patients in the laboratories they surveyed. Only a small minority (9.9%) reported having a formal policy identifying a threshold volume or threshold volume per unit time for the infusion of incompatible plasma.
Hemolysis in the setting of a smaller donor-plasma dose (RBC or whole blood-derived platelets) is far rarer, although there are reports in the literature. Brisk hemolysis apparently occurred in a Brazilian patient who received a single unit of group O RBC (55 mL of plasma), with an anti-A<sub>1</sub> titer of 1024 (AHG, saline). The donor’s RBCs had previously been transfused to a group A recipient without incident. In another case report, transfusion of 50 to 70 mL of whole blood-derived platelets containing a very high titer (16,000 AHG) anti-B resulted in hemolysis of 40 percent of the adult recipient’s circulating RBC mass. Two other case reports of pooled platelets causing brisk hemolysis are also interesting. The doses were four group O platelet units with a total volume transfused of 60 to 80 mL (anti-A<sub>1</sub> titers of 64 and 128 available for two units only [AHG]), and 10 platelet units (500 mL), with a pooled anti-A titer of 256 (AHG). In both cases the patient possessed a subgroup of A, presumably limiting the absorption of antibody by native cells and tissues to anti-A and rendering transfused A<sub>1</sub> RBCs more vulnerable.

The risk of a hemolytic reaction per unit of plasma-incompatible apheresis platelets has been calculated to be anywhere from 1 in 6600 to 1 in 9000. Clearly such calculations are empiric and fraught with potential error, as less overt or undetected hemolysis may occur, and some patients may be more at risk than others. Nonetheless, these are fairly small numbers when one considers that a titer of anti-A or anti-B high enough to be considered “dangerous” (16–600) is present in 10 to 20 percent of group O blood donors (various reports, AHG and saline). It seems likely that, although a high titer may be a prerequisite for trouble, there may be other aggravating factors that are important as well.

The notion of occasional “dangerous donors” with exceptionally potent antibodies is not a new one, and based on the handful of reports of serious hemolysis even with a small dose of plasma from such donors, it appears that no dose of incompatible plasma can automatically be assumed to be safe. In fact, one could argue that the use of group O RBCs in non-group O patients presents risk in the first place. Only with testing for high-titer antibodies (as is done in the United Kingdom) can this small but nonzero risk be removed.

In any case, the available evidence supports the model that as with platelets, hemolysis after the switch back to RBC of the patient’s native type would arise from the rare exposure to plasma from a “dangerous” donor as opposed to cumulative acquisition of low-titer antibody from multiple donors. Although a greater number of donors theoretically increases the very small risk of encountering such a donor, it does so to a very small degree. In fact, Fung et al. comment in their discussion that such an approach may stop passive accumulation of low-titer antibody from multiple donors but fails to prevent the infusion of high-titer antibody from a single donor. Hence as with platelet transfusion, for which most laboratories have not established volume limits for incompatible plasma, there is likely to be little benefit to these limits for RBCs.

Thus, one can fairly argue that the risk inherent to receiving incompatible plasma is inappreciably affected by the number of RBC units transfused and that based on the available evidence it is acceptable practice to switch back to the patient’s native type regardless of that number. If an arbitrary threshold is used, it should be consistent with the limit(s) imposed on other sources of incompatible plasma. These include apheresis platelets and testing of posttransfusion isoagglutinin titers, which should be considered, as these will be low most of the time and would obviate the need to honor the threshold. In the setting of chronic shortages, in which one must eliminate or significantly reduce unnecessary use of blood, there is a need to triage scarce resources rationally. Therefore, even those institutions using a threshold should consider relaxing it to address critically low supplies of group O RBCs.


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IN MEMORIAM

Sandra Sue Ellisor (Sandy), MS, MT(ASCP)SBB
1945–2007

Sandy was born and lived her first 6 years in Houma, Louisiana, a very small town south of New Orleans. She spent many hours outside every day on “safari,” exploring her surroundings with her crackers, her cookies, and her great curiosity. Her family moved to New Jersey and then to Indiana, where she finished high school.

Sandy received her bachelor of science degree in 1966 from Western Kentucky in Bowling Green and her medical technology certification (MT[ASCP]) in 1966 while at Norton Memorial Infirmary in Louisville, Kentucky. She moved to the West Coast to work at Irwin Memorial Blood Bank in San Francisco, California, and received her specialist in blood bank certification (ASCP[SBB]) in 1971. In 1984, she was awarded a master's in clinical science from San Francisco State with an emphasis on immunology and management, which would serve her well when she started her consulting business in later years.

In 1971, Sandy joined Spectra Biologicals, Inc., as a technical representative and consultant. In 1974, she joined the American Red Cross (ARC) Central California Region in San Jose as director of the Immunohematology Reference Laboratory (IRL) and Technical Education. As a knowledgeable teacher and lecturer and because of her great interest in education, she developed and implemented the SBB training program for San Jose. As the chairman of the National ARC IRL Committee, she oversaw the establishment of the criteria and measurement tools for the levels of regional IRLs. The high standards of reference laboratories in the ARC system are a tribute to her dedication and organization skills. She was also a founding editor of Red Cell Free Press, a technical newsletter that was distributed to all of the ARC IRLs. The newsletter later became Immunohematology, Journal of Blood Group Serology and Education, the only peer-reviewed and cited international journal published by the ARC.

Sandy's first adventure into the field of small business ownership began in 1979 when she opened Blood Bank Enterprises, an education consultation and technical writing business. She then returned to the ARC and moved to Baltimore, Maryland, where, between 1984 and 1991, she held the offices of director of Reference Laboratory, Technical Education, and Regional Compliance Office (dealing with all levels of compliance regulations), and finally, administrator of Scientific and Laboratory Services. She was now demonstrating her ability to administer and give operational directives to well over 100 staff members and to manage a multimillion dollar budget.

Another career change came in 1991 when Sandy joined Ortho Clinical Diagnostics, Inc., Raritan, New Jersey, a partnership that would last 10 years. She became technical marketing manager and would spend most of her career as the Biovue and RhoGAM Products technical marketing manager. In this capacity, she traveled the world.

In 2002, she was back on the West Coast and she started ss.ellisor enterprises, BLOOD BANK CONSULTATION. By now, she had a world of experience! She had done it all—regulatory, budgeting, management, administration, reference laboratory, marketing, training, writing, and teaching. In addition, she was manager of her own business until her death in November 2007.
Sandy gave many talks locally and at the international level. She had many peer-reviewed papers published and was on numerous committees, including the California Blood Bank Society (CABB) and the AABB. She also was an active member of the Invitational Conference of Investigative Immunohematologists for a number of years. The honors for her contributions to the field of immunohematology include the CABB Owen Thomas Memorial Award in 1988, and the Pennsylvania Association of Blood Banks presented her with the Lyndel Molthan, MD, Memorial Award. In 1989, the AABB presented her with the Ivor Dunsford Memorial Award for her technical expertise.

Sandy was an amazing and interesting person in many ways. She was an avid and excellent bird watcher who introduced many colleagues to bird watching early in the morning, before technical meetings. She loved to hike, camp (especially at Yosemite, which was one of her favorite places), read a good mystery, and capture on camera all the wildflowers, which she knew by name. She was a “crab-addict”! This was a great food love that she acquired in her youth and she taught many of us how to crack, eat, and suck out every shred of good meat from each crab. But she was the only one who ever loved the yellow she-crab fat! She was stubborn and principled! In fact, she gave up a job one time because of principle. Of course, her hallmark was her amazing laugh. From this tiny person came a huge and distinctive laugh that could be heard and remembered forever.

Sandy will be remembered with great fondness and admiration by all who were her friends and who benefited from her many and varied contributions to immunohematology.

Delores Mallory, MT(ASCP)SBB
Emeritus Editorial Board

The family and friends of Sandy Ellisor have requested that contributions in Sandy’s name be made to the following:

1. The Audubon Society (for her love of birds).

2. Chihuahua Rescue & Transport at: CRT, Inc. 3414 Pemberton Dr., Pearland, TX 77584 (the people who took care of and found homes for her pets).

3. An educational fund to encourage novice technologists to pursue a career in immunohematology. Checks can be made to NYBC with “PocketBook education fund” on the memo line. Send to Marion Reid, Immunochemistry, NYBC, 310 East 67th St., New York, NY 10065.
Sandy was one of my first SBB students. I came to San Francisco in August 1968, and even though not working at the Irwin Memorial Blood Bank, I soon got involved in teaching in the SBB program. I vividly remember Sandy as one of the brightest students; she graduated in 1971. My associations with Sandy continued throughout her career. After graduating, Sandy took a job in Oxnard, California, with the Reference Lab at Spectra Biologicals. Peter Issitt had worked there previously, and he wrote the first edition of *Applied Blood Group Serology* (published in 1970) there.

Once again, I had close contact with Sandy. The supervisor of the reference lab had a terrible fatal accident on the way home from work, and Spectra asked me if I could come down from San Francisco, once a month, to review the reference lab cases and provide continuing education (e.g., a lecture) to their staff. I had a chance, once again, to appreciate Sandy's technical expertise and to get to know her better at a personal level. Among many, many students, Sandy stands out in my memory, both technically and personally (who could forget that laugh). I was able to continue my close contact with Sandy when she moved back to Northern California in 1974 to join the Red Cross in San Jose (together with Marion Reid). Coincidentally, in 1978 I moved to join the Red Cross in Los Angeles and have lived there ever since, quite near Oxnard; it brings back memories every time I pass the little Oxnard airport where Sandy used to pick me up.

I was going through my files of reprints last week and came across a reprint, “Action and Application of Enzymes in Immunohematology,” from “A Seminar in Antigen-Antibody Reactions Revisited,” AABB 1982, by Sandra Ellisor. I had invited Sandy to give this talk at the Annual Seminar that was built around the Emily Cooley Award lecture (Ed Steane); there was an audience of approximately 2,000, a daunting task for anyone. Sandy had written on the front of the reprint, “George, this was a marvelous day for me! Best Wishes, Love Sandy.” The 40-page review is a tour de force and I still give it to our SBB students to read; Sandy had come a long way from the young student I first encountered in 1970.

As Delores Mallory mentioned in her obituary, Sandy went on to have a varied and interesting career. She was widely respected for her expertise in many areas, but my most vivid memories are of the cocoon changing into a butterfly in the 1970s and 1980s (I can hear Sandy's guffaw from here)!

George Garratty, PhD, FRCPath
Scientific Director
American Red Cross Blood Services
Southern California Region
Pomona, CA

It was her laugh. It was distinctive. It was more than a response to humor; it was a response to life itself. It could fill the largest room and be clear as a bell to all present. It was extremely distinctive and you would know instantly that Sandy was present. When you saw her, the first sight was always of a big, toothy smile causing her round cheeks to redden and causing her to squint her eyes; she even laughed with her eyes. She brought life with her wherever she went.

I met Sandra (Sandy) Ellisor at the first AABB Reference Laboratory Conference we both attended. As a couple of the neophytes in a room of renowned and prominent blood grouping serologists of the time we were bonded by similar circumstances, interests, and experiences; a strong interest in red cell serology; and the challenge of resolution of complex serological problems. While our employers, job titles, and responsibilities changed over the following 37 years,
she was just as faithful to her original professional purpose, quality performance and dissemination of information on methods of red cell serology and the valued services of blood banking, as she was when I first met her.

I have many fond memories of Sandy. One of the several that emphasized her humor to me occurred as various members of the assembled reference laboratories mentioned above were to depart to their homes following the meeting. Sandy and I both were in the same airport terminal area before our departure; mine to Minneapolis and Sandy to Oxnard via Louisiana. In addition to her luggage, which she had checked as baggage, she was carrying a liquid nitrogen transfer container containing frozen red cell samples. (The conference had been a “wet workshop” where participants brought unusual samples for further investigation and peer-review comments.) The container was about a 6 by 18 inch cylinder with a metal carrying handle. It was white with a small label that said “Cryogenic Carrier.” While we were waiting I had written on it “Human Semen Samples” and we debated if anybody would stop and ask her about the strange container. Later she confirmed that she had boldly carried it all the way to Oxnard and nobody asked her anything about the container or its contents. Needless to say, that was at a time of less restriction of materials carried on planes.

Sandy was just as capable of practical jokes. When she heard I was interested in looking at the protecins in snails and slugs, she sent me several large banana slugs she had collected while on one of her hiking trips. The smell of the freshly opened nonrefrigerated container of 4-day-old dead slugs influenced my limiting and eventual abandonment of any further studies into snail and slug protecins. Unknowingly, Sandy has saved dozens of my fellow workers from having to endure messy extraction procedures and odoriferous concoctions looking for various hemagglutinins and for that I am sure they are all eternally thankful.

While her overall contributions to the profession of serology, transfusion, and blood banking are numerous and noteworthy I know that that is recorded elsewhere. For me, I want to acknowledge and always remember the woman; a capable, ingenious, hard-working, and living life to the fullest friend. She truly gave much more than she took.

And to me, she gave the memory of her laugh, her smile, and being. It’s a memory that I will always cherish.

Sandy, we all miss you.

John J. Moulds MT, (ASCP)SBB
Director, Scientific Support Services
LifeShare Blood Centers
Shreveport, LA

Sandy Ellisor was a warm, loving, generous person whose personality was tempered with a healthy measure of cynicism and underscored by her famous laugh. For me, she was a very important part of my settling in the USA in 1990 when she lived in Baltimore, just a 45-minute drive from the Holland Laboratory in Rockville and its environs, to which I had moved from England. Marion Reid had “introduced” me to Sandy. Marion was living in Oxford at the time, and when I decided to move, she told me to look Sandy up and that Sandy would help with anything. I’m not sure she had told Sandy that but I never found out or even asked! Sandy was indeed generous. When she and her Mom spent a rainy two weeks in England, I house-sat for her, commuting from Baltimore to Rockville for one week and working as a guest in the ARC Baltimore Reference Laboratory for the second week. I looked after her two cats, drank beer on her back porch in the evenings, and enjoyed being a part of downtown Baltimore. She lent me her car during that period and I took my Maryland driver’s test, making me a legitimate right-hand-side driver!

Several memories stick out from that time. Eating Maryland crabs is a strong one. Delores Mallory, Deanna Fujita (who worked for the HLA Lab in the Holland Laboratory), Peter Byrne, and I would drive up to Baltimore to eat crabs with Sandy. The first time, she gave a demonstration to the uninitiated on how to break open a crab and what to eat (and she ate more of the crab than most) and then launched into them. She could eat crabs, talk, and laugh faster than anyone I’ve met since. It was always a fun evening. Another great set of memories are the weekends we used to go to Cape May in New Jersey to go birding with Polly Crawford. As an aside, Polly and many members of her family were In(Lu) types of the Lu(a–b–) phenotype. She would have been delighted to know that the molecular basis for the phenotype has been recently discovered, and it is the
first example of a mutation in a transcription factor that leads to a blood group phenotype.\textsuperscript{1} Quite aside from her rare blood group, Polly was an avid birder and had a family home in Cape May. Groups of us, which always included Sandy, used to go for the weekend during the migratory season and look at the lovely ducks, starting at the crack of dawn. I did not admit these weekends to my friends in England—“twitching,” as it’s called there, is a very nerdy thing to do—however, those weekends were great fun and I can still name most ducks to this day.

Professionally, Sandy and I never worked together; however, she was always a great sounding board for both frustrations and ideas, especially in my “early” years but also later when we didn’t meet so often. She provided encouragement and a sound opinion whenever I needed one. She was a great model in that she would try anything and try hard to make it work and I loved her optimism. I continue to miss her and know that I am one of many.

\textit{Jill R. Storry, PhD  
Blood Center, University Hospital  
Lund, Sweden}

\textbf{Reference}


I was extremely fortunate to have known Sandy Ellisor. As a teacher, committee member, and work associate, she influenced me in many ways, all of them with positive impact on my personal development and professional career.

I first met Sandy as a transfusion medicine fellow at what was then the Irwin Memorial Blood Bank in San Francisco, now known as the Blood Centers of the Pacific. Through her lectures at Irwin and presentations at the California Blood Bank System annual meeting, she became one of my earliest and best influences in immunohematology. She had a unique ability to emphasize what was important rather than to intimidate us with irrelevant detail.

I was fortunate to serve with Sandy as a member of the Scientific Section Coordinating Committee of the AABB. I had left California and taken my current position at Johns Hopkins at that time, but I had also recently accepted the directorship of the Chesapeake Region of American Red Cross Blood Services. One of my immediate goals and challenges was to change the ARC in Baltimore to emphasize customer focus and education. During a casual conversation with Sandy, I learned that she was willing to consider leaving paradise in California for new professional challenges in our Maryland paradise #2. I offered her a chance to come to Baltimore, and I have been eternally grateful that she accepted that challenge.

She began as our reference and education director and grew to positions of greater responsibility, managing all of our laboratory activities. These were the times of early turbulence in blood center management, with the AIDS epidemic, blood center consolidations, and heightened regulatory scrutiny by the FDA and other agencies, compounded by complicated management interactions in the ARC. Sandy led us through implementation of testing for HIV, HTLV, and HCV. When ARC national headquarters decided to close the Washington region and transfer most of the activity to Baltimore, leading us to form the Greater Chesapeake and Potomac Region, she enabled us to handle the major growing pains without undue distress. The hospitals and patients of the region owe Sandy a tremendous debt of gratitude for helping us transform the region at those difficult and challenging times.

When she and I left ARC, we remained in contact and interacted on consultative activities when she was at Ortho and later while working for her own business. I continued to learn many lessons from Sandy, always respecting her advice and welcoming her friendship. I miss Sandy and regret that I can no longer pick up the phone to seek her advice, but memories of her can-do attitude, sound and logical thinking, and enthusiasm for life will never leave me.

\textit{Paul M. Ness, MD  
Baltimore, MD}

\textbf{Sandy Ellisor: A Remembrance}

As this issue of Immunohematology is dedicated to Sandy Ellisor and contains an obituary, I chose to share some of my personal thoughts about this special person.

I first met Sandy in 1972, and what became immediately apparent was her trust and generosity to other
people, even strangers. For instance, after I drove across the USA for 3 months with a friend, we arrived with no place to stay and very little money—the day before Sandy traveled to Washington, DC, to attend the ISBT/AABB meeting. Without a second thought, Sandy left the keys to her apartment and car for us to use while she was away! Another example occurred several years later when I spoke with a colleague who was apprehensive about moving from England to the USA; without hesitation or reservation, I said, "If you need anything, just ask Sandy Ellisor."

We worked together in the Consultation Laboratory at Spectra Biologicals in Oxnard, California, and later in the Reference Laboratory at the Central California American Red Cross facility in San Jose. There Sandy was instrumental in running an active antibody club, and she developed and maintained an SBB school. Many graduates of the SBB school became successful immunohematologists and have continued to contribute to our field of medical technology, just as Sandy did.

Pertinent to the journal *Immunohematology* is the fact that Sandy (together with Helen Glidden and me) started its predecessor, a newsletter called *The Red Cell Free Press*. This newsletter was intended to be written by reference folk for reference folk, and it served that role for several years. Thus, it is a fitting tribute to Sandy that this issue of *Immunohematology* is dedicated to her legacy.

On the personal level, Sandy's family (sisters Margaret and Elizabeth and mother Ruth) were equally hospitable. Their warm reception made me reluctant to follow my initial plan of traveling around the world before returning to England to work as a medical technologist. Sandy believed in my abilities more than I believed in myself, and she encouraged me to report unusual findings and to speak in public (which was something I had resisted for years). Sandy's belief in me is something I shall forever remember and cherish. In fact this was a major contributing factor in my career development as an immunohematologist.

I certainly was not the only one who benefited from Sandy's warmth, generosity, and heart of gold. More than most of us appreciate, I believe that she helped many people to achieve goals that were far beyond their wildest dreams. It is impossible for me to convey in simple sentences and paragraphs the essence of Sandy or the extent to which she helped others. Below are a few haiku in which I have tried to impart some of the essence of who Sandy was and what she stood for.

Colleague, coworker, encourage, teacher, mentor supporter and friend

Ran SBB school Happy to mentor students Freely shared knowledge

Happy-go-lucky, optimistic, free spirit, goal-oriented

To be included, she would say, "Me too, me too!" Enthusiastic

Most infectious laugh; easy to find in a crowd! Brought smiles to many

Supported causes; helped whenever she saw need. So compassionate

Love for out-of-doors; backpacking, camping, hiking, Yosemite peace

Travel, reading, cats, bird watching, photography, compliance, QC

Philosophy of life: live, love, and laugh; you will be dead long enough!

*Marion E. Reid, PhD*
*
*New York Blood Center*
*
*New York, NY*
A precisely matched blood transfusion is like a carefully chosen fine wine

M.E. Reid

Depending on the color of grapes used to make wine, and the length of time the extracted juice remains with the skins, wine can be white, rosé, or red. Similarly, blood components have different colors: RBCs are dark red, whereas platelets and plasma are yellow. Wine and RBCs are both categorized into types. Wine is categorized as dry, medium, sweet, or medium-sweet, and this information is on the label on the bottle.

Blood is categorized as being group O, A, B, or AB and as type D+ or D−, and this information is on the label on the bag. Despite obvious differences between wine and blood, such as wine is drunk and blood is transfused, and the characteristics of wine are somewhat arbitrary and can change with time, whereas the characteristics of blood are genetically determined and discrete, and they do not change, the comparison is nonetheless illustrative.

Wine and blood both have many other qualities. For instance, the qualities of white wine are described as fruity, light, crisp, and delicate, while red wine is more likely to be described as spicy, oaky, velvety, fruity, robust, and mellow. A single wine can have several qualities that can be present in various combinations. To detect qualities in wine, it must be tasted. To select a bottle of wine, we often rely on the opinion of an expert.

In blood, specific antigens are qualities associated with the different cells. Platelet-specific antigens (antigens, or qualities, found only on platelets) are called HPA-1a, HPA-1b, and so forth; HLA antigens (antigens, or qualities, found on platelets, on WBCs, and on some RBCs) are called HLA-B7, HLA-B27, and so forth; and RBC-specific antigens (antigens, or qualities, found on RBCs) are called C/c, E/e, S/s, K/k, Fy(a+)/Fy(b−), and so forth. To detect qualities in blood, it must be tested. To select a bag of blood, we must rely on the knowledge of an expert.

As with the qualities of different wines, antigens (qualities) on RBCs can be found in various combinations, e.g., C−, c+, E−, e+, S−, s+, K+, k+, Fy(a+), Fy(b−), or C+, c+, E−, e+, S+, s+, K−, k+, Fy(a−), Fy(b+). This illustration uses 10 antigens (characteristics), but there are more than 250 distinct antigens that we need to take into account when precisely matching blood. Thus, the combinations are almost innumerable. Whereas grapes with certain qualities can be selected and grown, it is not possible to “tailor-make” (or grow) RBCs. The qualities of RBCs are inherited from our parents and do not change. Thus, RBCs from many donors must be tested to find the combination of qualities needed.

Wine made from grapes grown in different geographic locations has different and overlapping qualities. Similarly, RBCs from people from different geographic locations have different and overlapping qualities. Thus, some combinations of qualities are more likely to be found in donors from certain...
When and why does blood need to be matched? When a patient makes an antibody to an antigen on RBCs, blood for transfusion to that patient must be selected to lack the corresponding antigen. A patient can make an antibody after exposure to RBCs through transfusion or pregnancy. The greater the number of transfusions and pregnancies a person has, the more antibodies he or she is likely to make. The more antibodies present in a patient's serum, the more antigens must be absent from the donor's RBCs used to transfuse that patient. Thus, as the patient receives many transfusions he or she can develop many antibodies, and the combination of characteristics in a unit of RBCs for transfusion needs to be closer and closer to the combination of antigens (characteristics) of the patient; hence the term, “precise match.” If blood is not correctly matched, it could be destroyed by the patient, with possibly catastrophic consequences. This can be compared with the wine connoisseur; the more different wines he or she tastes, the choosier he or she becomes.

A major difference between blood and wine is that wine is not a necessity in life but blood is. Each of us has a specific blood type with different qualities, and sometimes it is difficult to find the right match for a patient whose life is threatened by anemia. Therefore, a constant supply of donors is required to find RBCs with the correct combination of characteristics for a patient with antibodies in his or her serum. As with selecting a correct bottle of wine for a given occasion, for some patients (especially those who are transfusion-dependent and are chronically transfused) it is necessary to carefully test and select just the right bag of blood. Which wine is a “precise match” to your palette? The more discerning the palette, the more precise the wine selection should be. The more antibodies a patient has, the more precise the RBC selection has to be.

Another difference between wine and blood is that shelves of wine are usually full and can easily be restocked, whereas shelves of blood are often insufficiently stocked and donors are constantly needed to supply blood to patients who need it.

Thus, a wine connoisseur can be compared to a skilled blood banker; their skills are acquired over a period of apprenticeship, training, and considerable experience. Sandy Ellisor, to whom this brief article is dedicated, was both a connoisseur of wine and a skilled blood banker.

**Acknowledgment**

I thank Robert Ratner for help in preparing the manuscript and figures.

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**Marion E. Reid, Ph.D., Director, Immunohematology Laboratory, New York Blood Center, 310 East 67th Street, New York, NY 10065.**

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Blood Group Antigens & Antibodies

A guide to clinical relevance & technical tips

By

MARION E. REID AND CHRISTINE LOMAS-FRANCIS

The authors are using royalties generated from the sale of this pocketbook for educational purposes to mentor people in the joys of immunohematology as a career. They will accomplish this in the following ways:

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About the book

This compact “pocketbook” from the authors of the Blood Group Antigen FactsBook is a must for anyone who is involved in the laboratory or bedside care of patients with blood group alloantibodies. The book contains clinical and technical information about the nearly 300 ISBT recognized blood group antigens and their corresponding antibodies. The information is listed in alphabetical order for ease of finding—even in the middle of the night. Included in the book is information relating to:

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II. SCIENTIFIC ARTICLE, REVIEW, OR CASE REPORT WITH LITERATURE REVIEW

A. Each component of the manuscript must start on a new page in the following order:
   1. Title page
   2. Abstract
   3. Text
   4. Acknowledgments
   5. References
   6. Author Information
   7. Tables
   8. Figures

B. Preparation of manuscript
   1. Title page
      a. Full title of manuscript with only first letter of first word capitalized (bold title)
      b. Initials and last name of each author (no degrees; all CAPS), e.g., M.T.
         JONES, J.H. BROWN, AND S.R. SMITH
      c. Running title of ≤40 characters, including spaces
      d. Three to ten key words
   2. Abstract
      a. One paragraph, no longer than 300 words
      b. Purpose, methods, findings, and conclusion of study
   3. Key words
      a. List under abstract
   4. Text (serial pages): Most manuscripts can usually, but not necessarily, be divided into sections (as described below). Survey results and review papers may need individualized sections
      a. Introduction
         Purpose and rationale for study, including pertinent background references
      b. Case Report (if indicated by study)
         Clinical and/or hematologic data and background serology/molecular
      c. Materials and Methods
         Selection and number of subjects, samples, items, etc. studied and description of appropriate controls, procedures, methods, equipment, reagents, etc. Equipment and reagents should be identified in parentheses by model or lot and manufacturer’s name, city, and state.
         Do not use patient’s names or hospital numbers.
      d. Results
         Presentation of concise and sequential results, referring to pertinent tables and/or figures, if applicable
      e. Discussion
         Implication and limitations of the study, links to other studies; if appropriate, link conclusions to purpose of study as stated in introduction
   5. Acknowledgments: Acknowledge those who have made substantial contributions to the study, including secretarial assistance; list any grants
   6. References
      a. In text, use superscript, Arabic numbers.
      b. Number references consecutively in the order they occur in the text.
   7. Tables
      a. Head each with a brief title; capitalize the first letter of first word (e.g., Table 1. Results of . . . ) use no punctuation at the end of the title.

b. Use short headings for each column needed and capitalize first letter of first word. Omit vertical lines.
c. Place explanation in footnotes (sequence: *, †, ‡, §, ¶, **, ††).

8. Figures
   a. Figures can be submitted either by e-mail or as photographs (5 × 7 glossy).
   b. Place caption for a figure on a separate page (e.g. Fig. 1. Results of . . . ), ending with a period. If figure is submitted as a glossy, place first author’s name and figure number on back of each glossy submitted.
   c. When plotting points on a figure, use the following symbols if possible:
      ○ ● △ ▲ ■ □ ◢.

9. Author information
   a. List first name, middle initial, last name, highest degree, position held, institution and department, and complete address (including ZIP code) for all authors. List country when applicable.

III. EDUCATIONAL FORUM

A. All submitted manuscripts should be approximately 2000 to 2500 words with pertinent references. Submissions may include:
   1. An immunohematologic case that illustrates a sound investigative approach with clinical correlation, reflecting appropriate collaboration to sharpen problem solving skills
   2. Annotated conference proceedings

B. Preparation of manuscript
   1. Title page
      a. Capitalize first word of title.
      b. Initials and last name of each author (no degrees; all CAPs)
   2. Text
      a. Case should be written as progressive disclosure and may include the following headings, as appropriate
         i. Clinical Case Presentation: Clinical information and differential diagnosis
         ii. Immunohematologic Evaluation and Results: Serology and molecular testing
         iii. Interpretation: Include interpretation of laboratory results, correlating with clinical findings
         iv. Recommended Therapy: Include both transfusion and nontransfusion-based therapies
         v. Discussion: Brief review of literature with unique features of this case
         vi. Reference: Limited to those directly pertinent
         vii. Author information (see II.B.9.)
         viii. Tables (see II.B.7.)

IV. LETTER TO THE EDITOR

A. Preparation
   1. Heading (To the Editor)
   2. Title (first word capitalized)
   3. Text (written in letter [paragraph] format)
   4. Author(s) (type flush right; for first author: name, degree, institution, address [including city, state, ZIP code and country]; for other authors: name, degree, institution, city and state)
   5. References (limited to ten)
   6. Table or figure (limited to one)

Send all manuscripts by e-mail to immuno@usa.redcross.org
Becoming a Specialist in Blood Banking (SBB)

What is a certified Specialist in Blood Banking (SBB)?
- Someone with educational and work experience qualifications who successfully passes the American Society for Clinical Pathology (ASCP) boards of registry (BOR) examination for the Specialist in Blood Banking.
- This person will have advanced knowledge, skills, and abilities in the field of transfusion medicine and blood banking.

Individuals who have an SBB certification serve in many areas of transfusion medicine:
- Serve as regulatory, technical, procedural, and research advisors
- Perform and direct administrative functions
- Develop, validate, implement, and perform laboratory procedures
- Analyze quality issues, preparing and implementing corrective actions to prevent and document issues
- Design and present educational programs
- Provide technical and scientific training in blood transfusion medicine
- Conduct research in transfusion medicine

Who are SBBs?
Supervisors of Transfusion Services
Managers of Blood Centers
LIS Coordinators
Educators
Supervisors of Reference Laboratories
Research Scientists
Consumer Safety Officers
Quality Assurance Officers
Technical Representatives
Reference Lab Specialist

Why be an SBB?
Professional growth
Job placement
Job satisfaction
Career advancement

How does one become an SBB?
- Attend a CAAHEP-accredited Specialist in Blood Bank Technology Program OR
- Sit for the examination based on criteria established by ASCP for education and experience

Fact #1: In recent years, the average SBB exam pass rate is only 38%.
Fact #2: In recent years, greater than 73% of people who graduate from CAAHEP-accredited programs pass the SBB exam.

Conclusion:
The BEST route for obtaining an SBB certification is to attend a CAAHEP-accredited Specialist in Blood Bank Technology Program

Contact the following programs for more information:

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<thead>
<tr>
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<td>202-782-6210</td>
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<td><a href="mailto:Owang@giveblood.org">Owang@giveblood.org</a></td>
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<td>301-496-8335</td>
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