Procedural errors in antibody identification


In experimental studies of students and line technologists performing antibody identification procedures, both groups made errors. These errors included, at times, either failing to identify an antibody or misidentifying the specificity(ies). A prospective study was undertaken to identify errors made in a laboratory setting. Errors were classified as 1) failing to follow protocol (procedural error) or 2) arriving at the wrong answer (misidentification error). Over a 1-year period, 1,057 workups were reviewed. There were 41 (3.88%) procedural errors and no misidentification errors. In 25 workups (61% of errors), the selection of cells to rule out underlying alloantibody(ies) was in error. The remaining 16 involved various "slips" (minor mistakes or memory lapses) and clerical errors. Based on an analysis of the probable causes of these errors, potential solutions include 1) developing computer aids to detect "rule-out" errors or missing test results; 2) providing timely, careful review of workups before transfusion; and 3) designing better panel layout and cell selection.

Materials and Methods

Over a 1-year period, all workups (total 1,057) involving antibody identification by all 16 technologists in our crossmatch laboratory were reviewed. The technologists were all MTs(ASCP), and three also were SBBs. Eleven of the 16 individuals had 4 to more than 8 years of experience. The remaining five had 1 to 2 years of experience.

To identify errors, all workups were reviewed by a reference laboratory supervisor (SBB). The supervisor checked for two types of errors:

- Failure to follow the laboratory's standard protocol (procedural error)
- Arrival at an incorrect answer (misidentification error)

During the first identification procedure, the laboratory's protocol included using autologous controls, typing the autologous cells to determine Rh phenotype and other relevant antigens as required by the identity of the alloantibody(ies) found, performing "rule outs" by using nonreactive panel cells possessing a double dose of the relevant antigen, and performing "rule ins" by using at least three reactive antigen-positive test cells and three nonreactive antigen-negative test cells to confirm identification of the specific alloantibody. In succeeding workups on the same patient, only rule outs were done unless a new alloantibody was detected. In cases in which errors were identified, additional testing was done as needed to complete the workup.

A total of 1,057 problem workups were reviewed, and 41 errors in following the laboratory's protocol were
identified. Two errors were found in each of six cases, and three errors were found in each of two cases.

**Rule-out errors**

Twenty-five of the procedural errors involved rule outs. In two cases, the technologist selected a questionable cell for ruling out a particular antibody: to rule out anti-E, the cell selected was heterozygous for the corresponding antigen; and to rule out anti-Le^a, the Le^a cell selected was Le(a+wb+). In two other cases, the technologist erroneously ruled out two antibodies (anti-N and -C) because a heterozygous cell was tested.

In four cases, the technologist ruled out potential antibodies (anti-C, -Jk^a, and -S in each of three cases and anti-M and -S in the fourth case) using a cell that was actually reactive (because of the presence of another antibody).

In eight cases, the technologist failed to try to rule out a theoretically possible antibody (anti-S, -Le^b, -C, -K, -Fy^b, or three anti-Es). In another case, the technologist failed to rule out two antibodies (anti-Jk^a or -S) because she was relying on previous conclusions by another technologist who had used the same panel.

A similar error occurred when a technologist trusted the previous use (by another technologist) of a particular cell to complete certain rule outs, when in fact the previous technologist had made an error.

In six cases, the technologist identified a cell to test but either never completed the test or failed to record the results (anti-P^1 and -C in one case each, anti-S in three cases, and anti-C, -K, -Le^a in one case).

Finally, in one case the tested cell was not the same lot number as the cell that had been selected for testing (anti-Jk^b).

**Other procedural errors**

In two cases, the technologist failed to follow the laboratory's protocol, by not using or recording the results of check cells. In three cases, the technologist failed to run required antigen or Rh typings. In two cases, the technologist made a clerical error when entering results into the computer. There was one rule-in error when the technologist used only one antigen-positive cell to identify an antibody when a total of three should have been used. There were eight other miscellaneous errors, such as failing to antigen-type red cells, failing to test antigen-positive or rule-out cells on eluates following a proven delayed hemolytic transfusion reaction, or doing more testing than needed because of failure to note previous results.

**Misidentification**

During the 1-year period of the study, none of these errors in following the laboratory's protocol led to an incorrect final answer (see Discussion).

**Discussion**

The reasons for using specific panel cells can, of course, only be hypothesized on the basis of markings on the panel sheets, as the technologists were only rarely able to recall specific cases when later questioned. Those who were shown the panel sheets immediately saw the error and were able to point out why it was not the cell of choice. Also, an error was not repeated by the same technologist from one workup to another, indicating the technologist knew the rules but somehow "slipped" in the specific case. Even though these problems have been discussed with the technologists, such errors continue to occur regularly.

We postulate that on at least some occasions, the technologists intended to use one test cell on a panel (e.g., cell 3) but in fact looked at the antigens found on some other cell (e.g., cell 2 or 4). Similar slips may have occurred when the technologists scanned vertical columns on panels.

The two largest groups of errors, however, appear to have been caused by oversight. The technologists simply did not test the cells necessary to rule out certain specificities; or, having selected a specific cell, they forgot to include that cell when setting up the test tubes.

The technologists stated that they enjoyed doing antibody identifications because they are diverting, interesting, and different from routine procedures. However, they are also time-consuming, and because they are nonroutine they require extra effort. Thus, when antibody identifications are sandwiched between technologists' routine duties, errors may occur because attention is diverted from the identification to routine work or to emergencies.

Although some of the antibodies that were not ruled out in the original workups are considered to be insignificant (i.e., anti-Le^a, -Le^b, -P^1, -N), others such as anti-Jk^a or -Jk^b are usually considered to be clinically significant. They are often weak and may be missed if the red cells being crossmatched are heterozygous for the antigen. It was a matter of luck that during our 1-year study period, we found no additional antibodies even when we found an error in following the laboratory's protocol. For example, we found an anti-C accompanying an identified anti-D immediately after
this study was terminated. Furthermore, previous studies, as well as our pilot study, found instances in which the final answer was simply wrong.

Alternatives to consider in an effort to reduce the chances of error include some of the following:

- **Administrative procedures.** In our study, a supervisor reviewed all cases for evidence of errors. We do not know how many errors such a process misses, but it is clear that it can provide added protection if completed before transfusions.
- **Paper and pencil aids.** A second possible improvement would be to change the design of the panel sheets. It is plausible that at least some of the slips we discovered could be prevented by better layout of the panel sheets.
- **Computer aids for panel construction.** A previous experimental study suggested that in several cases where the technologist arrived at the wrong answer, a contributing cause was the presence of overlapping antigens on the panel cells, i.e., all K and E positive cells were also Fy(b+), and these were the only Fy(b+) cells on that panel. The technologist arrived at the incorrect answer in part because the correct antigens (K and E) were on exactly the same set of panel cells as was the incorrectly chosen answer (Fyb+). It would be a simple matter to design a computer aid that warned panel users whenever such problems were present on a panel.
- **Computer aids for technologists.** A fourth alternative would be to replace paper forms with computerized forms, thus increasing accuracy by requiring technologists to record test results and conclusions on a computer. This would make it possible to develop computer aids to assist the technologist.

Another solution would be simply to automate parts of the process. Given the test results, the computer could, for instance, apply the standard heuristics for rule out based on nonreacting cells and tell the technologist the answer. A hazard associated with this solution, however, is that the expertise of the technologist would be removed for this part of the process. That is, the technologist would no longer need to look carefully at the raw data and therefore would be less likely to spot an anomaly or an unusual situation that the computer was not programmed to detect.

An alternative that would keep the technologist in the process would be to build an aid that monitored the technologist's performance and simply called attention to cases where a slip might be involved. This type of cooperative system could be used as an aid during rule out based on nonreacting cells, as well as in the interpretation of antigen typings. The system could also monitor for answers that are rare (e.g., anti-C alone in an Rh-negative person) and for atypical findings in the data, given the technologist's answer. In all of these cases, the technologist would play the primary role in identifying antibodies. The computer would simply be an aid to alert the technologist when an unusual or atypical conclusion has been drawn.

**Conclusion**

The introduction of computer aids offers intriguing possibilities for reducing procedural errors. However, extreme care must be taken to ensure that in the process of reducing certain errors by introducing computer aids, a new source of errors is not introduced.

**Acknowledgment**

This research was supported by the National Heart, Lung and Blood Institute, NIH Grant HL38776.

**References**


Patricia L. Strohm, MT(ASCP)SBB, Ohio State University Hospitals, Columbus, OH; Phillip J. Smith, PhD (correspondence), Laboratory for Knowledge Based Medical Systems, Health Sciences Library, Room 571, 376 West 10th Avenue, Columbus, OH 43210; Jane M. Fraser, PhD, Thomas E. Miller, MS, Sally V. Rudmann, PhD, Jack W. Smith, Jr., MD, PhD, John R. Svibely, MD, Janice F. Blazina, MD, and Melanie S. Kennedy, MD, Ohio State University Hospitals, Columbus, OH.