# A Quality Improvement Cycle: Hemolyzed Specimens in the Emergency Department

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**OBJECTIVE:** To determine the cause of and possible solution for an excessive number of hemolyzed specimens received from the emergency department (ED) of a large medical center.

**DESIGN:** The clinical laboratory staff collected data on hemolyzed specimens for all departments of the medical center. The clinical laboratory management team and ED management team intervened with training and surveillance of the ED staff to heighten the awareness of the problem.

**SETTING:** The clinical chemistry laboratory of a large medical center.

**MAIN OUTCOME MEASURE:** The number of specimens submitted by inpatient departments and the ED was measured in relationship to the number of hemolyzed specimens received from the departments. The clinical laboratory measured specimen processing times and turnaround times to determine their role in possibly contributing to the large number of hemolyzed specimens. Direct observation by a certified phlebotomist documented anecdotal evidence of the ED staff's phlebotomy practices. ED and clinical laboratory practitioners communicated realistic impressions of the medical centers problem with hemolyzed specimens.

**RESULTS:** The laboratory processing times were not responsible for the hemolyzed specimens. The collection equipment was not responsible for the hemolyzed specimens. The ED had an excessive number of hemolyzed specimens when compared to the rest of the medical center. The collection techniques in the ED appeared to be the origin of the problem.

**CONCLUSION:** The intervention of the laboratory manager with the ED chief and nurse manager abated some of the professional arrogance between the departments. The dialogue educated the staffs about specific data that pointed to a possible origin of the problem. The ED chief placed his department on surveillance against problematic draws. Communication was improved between the two departments. However, only a moderate improvement in the number of hemolyzed specimens was noted. More training of medical center departments in phlebotomy and periodic proficiency evaluation of the all staff was indicated as a possible long-term solution.

**ABBREVIATIONS:** CLT = clinical laboratory technician; CLS = clinical laboratory scientist; ED = emergency department; HIS = hospital information system; LIS = laboratory information system; RBC = red blood cells; SOP = standard operating procedure; TAT = turnaround time.

**INDEX TERMS:** data-derived guideline; emergency department; evidence-based practice; hemolyzed specimens; specimen collection.

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Hemolysis is the breakdown of red blood cells (erythrocytes, RBCs) and the subsequent release of hemoglobin that normally occurs at the end of the life span of a red cell.[1] Physiologically, hemolysis can occur in several disease states such as glucose-6-phosphate dehydrogenase or hexokinase deficiency. Mechanical hemolysis due to inappropriate phle-

botomy causes falsely elevated test results for many analytes. In both cases, analytes leak from erythrocytes into the extracellular environment altering concentrations of cellular and extracellular substances. Some laboratory tests that are affected by hemolysis include iron, magnesium, potassium, ammonia, hemoglobin, bilirubin, acid phosphatase, lactate dehydrogenase, and clotting factors.[2-4]

When hemolyzed specimens are analyzed, the accuracy and reliability of test results are drawn into question. Therefore, the quality of patient specimens is an important determinant in laboratory testing. In most clinical laboratories, hemolyzed specimens cannot be used for testing in blood bank, coagulation studies, and most chemistry procedures.[2]

Hemolysis in blood specimens can be caused by improper collection techniques or improper specimen transportation and storage conditions during the preanalytical phase. The preanalytic phase of laboratory testing accounts for 46% of laboratory testing errors.[5] Causes of hemolysis during this phase can be categorized into specimen procurement and specimen handling.[6] This investigation explored the potential causes of specimen hemolysis by evaluating the procurement and handling of specimens in the emergency department (ED) of a large medical center. Data derived from this investigation were used to evaluate operational efficiencies in the ED and the clinical laboratory. The purpose of this study was to investigate, document, and evaluate the number of hemolyzed specimens collected for both the ED and the clinical laboratory.

This investigation addressed the following ED staff complaints: 1) processing delays of the laboratory staff was the chief reason for excessive numbers of hemolyzed ED specimens, and 2) receiving results from ED specimens consistently took over one hour (the published target turnaround time). The laboratory complaint was that the number of hemolyzed specimens was excessive for the ED when compared with specimens collected in the other departments.

A four-step process was employed to address ED and laboratory complaints: 1) the number of hemolyzed specimens received by the laboratory was totaled and categorized by department for a two-month period, 2) specimen processing and turnaround times (TAT) were evaluated for adherence to protocol and/or invalid procedure steps, 3) a certified phlebotomy staff was sent to the ED to observe collection protocol and train the personnel collecting blood, 4) ED and laboratory managers met to discuss the evidence and evaluate the need for operational changes in procedures. Data derived from this study were used to develop an evidence-based dialogue between the emergency department and the clinical laboratory.

## METHODS

The total number of hemolyzed specimens received by the laboratory was evaluated. The standard operating procedure (SOP) for laboratory receipt of specimens required the documentation of the following; date, time of receipt, location of specimen origin, patient's name, type of test, and nursing staff's name who delivered the specimen to the laboratory. Data collected over a two-month period were evaluated by totaling the number of specimens received (affected and non-affected) and assigning percentages of specimens hemolyzed based on the department of origin. The departments involved were the ED, the surgical intensive care unit (SICU), medical intensive care unit (MICU), 9th Floor West (9W), 5th Floor East (5E), cardiology, 10th Floor West (10W), 3rd Floor East, same day surgery (SDS), oncology, nephrology, and the family practice clinic. Data were categorized to determine if there were particular time periods in which the occurrence of hemolyzed specimens was more prominent. Standard phlebotomy equipment was used for all departments. No capillary or arterial punctures were included in the data, only venous draws.

Specimen processing time and TAT were evaluated. The SOP for receiving specimens differed for first shift when compared to second and third shifts. During the first shift, specimens were delivered to the specimen processing room where technicians logged in, centrifuged, aliquotted, and categorized specimens for delivery to the appropriate laboratory sections. Specimens were logged into the laboratory upon arrival. During the second and third shifts, nursing staff transported specimens to the chemistry section. Nursing staff logged specimens into the accession log book with the following data; date, time of arrival in the laboratory, patient's name, test ordered, origin of the specimen, and nursing staff's name. At this point, specimens were usually left on the counter waiting processing by the clinical laboratory scientist (CLS) or clinical laboratory technician (CLT) on duty. The laboratory staff transferred demographics, including specimen receipt date, time, and location, from the accession log into the laboratory information system (LIS). The LIS generated labels from orders that had been entered into the hospital information system (HIS). Immediately after login, specimens were mechanically centrifuged at 3000 rpm for 10 minutes at room temperature. In most cases, specimens could be taken directly from the centrifuge to the analytic

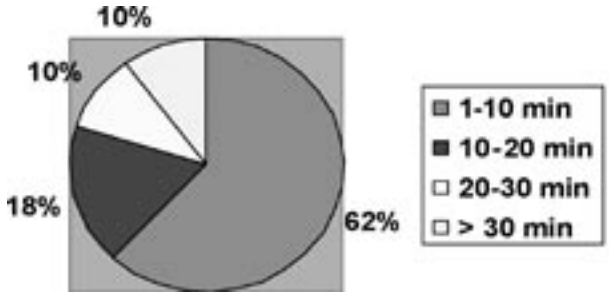
phase. For measurements on different analyzers, specimens were aliquotted into appropriate volumes and containers before the analytical phase.

The accession log book and LIS logs were compared to address the ED complaint that specimens were hemolyzed because they sat on the counter for long periods of time. The "counter-time" was the amount of time specimens sat on the counter before laboratory staff processed specimens into the lab. The counter-times were the difference between the accession log book receipt times and the LIS login times; counter-times were further categorized into four groups; 1-10 minutes, 10-20 minutes, 20-30 minutes, and greater than 30 minutes. Counter-times were also correlated with the number of technical staff on duty; four technical staffers or five to six technical staffers.

The LIS log entries and the release of test results were routinely correlated by the chemistry section supervisor into the STAT TAT report that was presented at the monthly laboratory quality assurance meeting. These evaluations were part of the laboratory's ongoing quality improvement program and were readily mined for this investigation. Because all ED specimens were treated as STAT, the ED had a separate STAT TAT report from the other hospital departments.

A certified phlebotomist was sent to observe phlebotomy practices in the ED. The phlebotomist evaluated two quality

**Figure 1.** How long are specimens sitting on the processing counter?




Graph showing the average time specimens sit on the counter before they are accessioned into the laboratory. The majority of specimens (80%) are processed into the laboratory within 20 minutes.

**Table 1.** Hemolyzed and STAT specimens received by department and shift

| | Total # of specimens submitted to the laboratory | Total # of hemolyzed specimens received | Percentage of hemolyzed specimens | Total # of STAT specimens submitted | Percentage on time STAT TAT |
|---|---|---|---|---|---|
| **Emergency department** | 1075 | 195 | 18.1 | 501 | |
| Shift 1 | * | 61 | * | 188 | 95 |
| Shift 2 | * | 87 | * | 199 | 89 |
| Shift 3 | * | 33 | * | 114 | 92 |
| **Other departments** | 9249 | 69 | 0.7 | 1586 | |
| Shift 1 | * | * | * | 491 | 92 |
| Shift 2 | * | * | * | 365 | 86 |
| Shift 3 | * | * | * | 730 | 91 |
| **Total** | 10324 | 264 | 2.56 | 2087 | |

*Data not collected.

indicators: 1) the number of problematic draws increasing the risk of hemolysis and 2) proper equipment and technique utilization during the blood collection protocol. The phlebotomist documented findings and made on-the-spot recommendations to staff for correcting any observed difficulties.

## RESULTS

The ED submitted significantly more hemolyzed specimens to the laboratory. Total number of specimens, total number of hemolyzed specimens, percentage of hemolyzed specimens, total number of STAT specimens submitted, and percentage of on-time STAT are presented in Table 1. The average counter-time for all departments, including the ED was approximately 15 minutes. Figure 1 summarizes counter-times for all departments. Counter-times were equivalent when four people staffed the laboratory or whether five to six people were working.

Supplemental phlebotomy training was offered to the ED staff; however no one on the ED staffed received additional training. Anecdotal observational data from the certified phlebotomist indicated that ED personnel used proper techniques in blood collection. ED staff correctly used personal protective equipment, recommended needle gauges, evacuated collection tubes/syringes, and butterfly assemblies. An instance was observed when blood was drawn into a syringe and then forced into an evacuated tube. On the spot correction was administered.

The laboratory manager, clinical chemistry supervisor, ED chief, and ED nurse manager met to discuss outcomes of the investigation and to formulate changes to the operating procedures. Data were presented that documented the following: 1) the number of hemolyzed specimens per location relative to those from the ED, 2) the correlation of specimen processing times and STAT TATs in order to evaluate whether extended laboratory processing times contributed to specimen hemolysis, and 3) anecdotal qualitative blood collection observations. A plan was crafted to more effectively coordinate laboratory and ED blood collection services.

## DISCUSSION

Data show that the ED submits approximately one-tenth of the total number of specimens submitted by all the departments to the laboratory. However, the ED has significantly more hemolyzed specimens (74%) of the total number of hemolyzed specimens for the study period. Laboratory processing is the same for all specimens. If laboratory processing is causing the hemolysis, one would expect the other hospital departments to have higher percentages of hemolyzed specimens. Looking at only the specimens submitted by the departments, the hemolysis rate is 0.7% (69 hemolyzed specimens/9249 specimens) for the evaluated period. The ED rate is 18% (195 hemolyzed specimens/1075 specimens). Also, the total number of hemolyzed specimens from other departments is low when compared to the total number of hemolyzed specimens for the ED (Table 1). It is possible that an individual department may have a hemolysis rate comparable to the ED rate; however, total specimen numbers for each department were not captured. Considering the significantly higher number of specimens submitted from the departments (9249 specimens vs. 1075 specimens), it is unlikely that any individual department matches or exceeds the ED rate. Even if this is the case, it would suggest a collection problem in both the ED and that department.

Processing time and counter-time data do not support the ED position that excessive hemolysis is due to delayed specimen processing. Counter-times for 89% (800 specimens/896 specimens) of all specimens is less than 30 minutes and for 80% (727 specimens/896 specimens) less than twenty minutes. The majority of specimens, 62% (552 specimens/896 specimens), wait on the counter less than ten minutes. ED specimens are given priority over routine specimens. Counter-times could be a cause of hemolysis; however, specimens would have to sit many hours on the counter before they would hemolyze.[7] On all shifts, ED specimens are treated as STATs with an applied turn-around time benchmark of 60 minutes. Data for all three shifts in the laboratory indicate that the turn-around time for ED specimens met or exceeded the benchmark of ninety-percent (90%) for the two month period of data collection.

The causes of hemolyzed specimens cannot be conclusively associated with an overall lack of phlebotomy skills as speculated by the laboratory manager and staff. Phlebotomy skills for the ED staff demonstrate good training and proper use of phlebotomy equipment as documented by two days of close observation by a certified phlebotomist. There are some occasions when the ED staff uses the technique of forcing blood into an evacuated tube from a syringe. This technique is not endorsed by the ED, but is used sometimes. This is the suspected cause of excessive hemolysis in the ED. However, another factor that may have a significant impact on the number of hemolyzed specimens is the site of the draw. Certified phlebotomists are trained to draw at the antecubital fossa. It is conceivable that draws from more distal areas may contribute to the problem.[8] Though the certified phleboto-

mist did not observe this during his observation of the ED, it cannot be ruled out. Observation was not completed for all ED shifts since the phlebotomy staff is employed only on the day shift.

Most healthcare organizations use a combination of centralized and decentralized phlebotomy services.[9] Decentralized phlebotomy has been blamed for a myriad of problems associated with specimen quality.[10] The laboratory manager's claim that the ED has excessive numbers of hemolyzed specimens in comparison to the other hospital departments is supported by the data. This was the first time that the ED and laboratory services have evaluated empirical data on the number of hemolyzed specimens and both services were enlightened as to the extent of the problem. These data do not point to a laboratory origination of compromised specimens as suggested by the ED. Data do not point to specific problems in processing such as centrifugation. The data show that the laboratory manager's complaints are indeed valid and that the problem is distinct to the ED.

As above, counter-time does not appear to be the cause of hemolyzed specimens. Further, delays in specimen processing are not usually reported to cause hemolysis.[7] ED staff makes multiple trips to the laboratory during the second and third shift. With specimens being delivered from all hospital departments to this central location, the impression could be that laboratory accessioning was inefficient. Though this impression is understandable, it is more likely that hospital staff is looking at different specimens on each trip to the laboratory. Additionally, TATs are well within the benchmark established by the Quality Assurance Committee. Ninety percent of all ED specimens considered STAT are reported within 60 minutes even when processing times are included. TAT greater than 60 minutes are sometimes seen during evenings and nights when laboratory personnel have specimens that may require extra time, such as manual differentials.

TAT is also increased when compromised specimens, hemolyzed or short sample, are submitted by any department and the specimen must be redrawn. Hemolysis is usually detected after the centrifugation process. When hemolysis is discovered, laboratory staff can only wait for another specimen to be submitted to replace the compromised specimen that has already been logged into the department. Routinely, there are three laboratorians on the second shift and two on the third shift. Specimen processing and TAT did not fluctuate depending on the number of laboratorians staffed on off-shifts. The number of ED specimens (all ED specimens are treated as STAT) received for the day and evening shift are approximately equivalent. ED specimens for the night shift are two-thirds to one-half the number received for the day and evening shifts. Increases in TAT relative to ED specimens are likely caused by a higher incidence of hemolyzed specimens. However, the overall number of test results taking greater than one hour is less than 10% in most cases. Again, this is well within the laboratory's benchmark for quality.

A key element for improving specimen quality is to improve the collaboration between departments and laboratory services. The data presented during the laboratory and ED meeting resulted in a better understanding of the problem of hemolyzed specimens and informed both services about inaccurate representations about both departments. Communication is often an obstacle between hospital departments. One of the major problems facing improvements of medical errors is resistance to the implementation of corrective action.[7] No department wants to accept responsibility for problems.[11] Lack of reception to new ideas, professional arrogance, power struggles between departments, and lack of incentives to change are a few of the reasons that corrective actions are so hard to implement.[7] This was true in the case of this investigation as well. The laboratory and the ED could not agree on any specific course of action. The laboratory manager offered continued education in phlebotomy practices; however, the offer was declined. Though data showed that the laboratory not was responsible for the excessive number of hemolyzed specimens, the ED retained their position of no-fault. It is for this reason that collecting evidence to guide the practice of departments is so important. The solution for such resistance between departments is to raise the level of attention to a hospital-wide quality assurance committee. This would de-emphasize interdepartmental struggles and put the focus back on quality of care.

Despite professional differences, communication did improve between the two departments after this quality improvement investigation. This was the first time that the departments had cooperated to solve the hemolyzed specimen problem. This was a "real life" project implemented in the middle of a working environment. A lesson learned was that more data should have been collective by both departments. Despite the amount of data collected, the intervention of the laboratory manager with the ED chief and nurse manager opened a dialogue between the two departments that has had the impact of putting both laboratory staff and emergency department staff on alert about the problem. The ED chief used these data to describe the existing problem. Emphasis is now placed on

the common causes of hemolysis and avoiding blood collecting techniques that are known to be problematic. Specific emphasis is now placed on avoiding forcing syringe drawn specimens into evacuated tubes.

## CONCLUSION

Quality improvement data show that the ED submits large numbers of hemolyzed specimens relative to the other hospital departments. The data also show that no laboratory processes, such as counter-times and TAT, are extended relative to the ED and other departments. The data do not indicate correlation of any specific laboratory practice with hemolyzed specimens. Therefore the most likely cause of hemolysis is in the specimen collection practices of the ED, specifically, higher number of syringe drawn specimens that are forced into evacuated tubes.

The future direction and solution of this study is to make the issue a hospital-wide focus. If a hospital department feels it is not being singled out, it will be more willing to cooperate.[11] In this investigation, resistance between the laboratory and the ED was an obstacle that could only be dealt with by an evidence-based investigation. Without evidence, the departments' complaints disintegrate into a "blame-game". Both departments were surprised by the extent of the problem when the ED was compared to other hospital departments. Presentation of findings resulted in a more active surveillance of collection techniques typically employed as short-cuts in the ED. However, this surveillance has not led to a significant decrease in hemolyzed specimens since the conclusion of this investigation. A stronger intervention is required to overcome the deeper roots of departmental resistance.

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