A Single-Center Prospective Study of the Effects of Different Methods of Phlebotomy in the Emergency Department on Blood Sample Hemolysis Rates

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Contribution to Emergency Nursing Practice

- Blood sample hemolysis causes re-collection of blood samples and prolongs the length of stay of patients in the emergency department.
- The use of 20 gauge intravenous catheter and Luer-Lock access device is effective in reducing blood sample hemolysis when blood is drawn from the intravenous catheter.
- Using a steel straight needle is best practice to reduce blood sample hemolysis, but if not possible, use of Luer-Lock access device and a larger bore intravenous catheter is better than a smaller one. This should lead to fewer delays in treatment and discharge.

Abstract

Introduction: Hemolysis is more commonly seen in the emergency department and causes delays in diagnosis, hospitalization, discharge, and treatment of patients. The aim of this study was to determine the most appropriate phlebotomy method and device to reduce blood sample hemolysis in the emergency department.

Methods: This prospective, comparative descriptive study involved patients who presented to the emergency department with any medical condition and required blood sampling. Patients were divided into 6 groups according to the method of phlebotomy and the device used for phlebotomy. Data were analyzed with logistic regression.

Results: A total of 715 patients participated in the study. The blood sample hemolysis rate in the emergency department was 25.7%. When the hemolysis rates were compared with a steel straight needle or intravenous catheter, it was found that the use of steel straight needle significantly reduced hemolysis. Blood drawing through a 20 G intravenous catheter with Luer-Lock access device reduces the risk of hemolysis. Male sex and difficult blood collection also have been shown to increase the risk of hemolysis.

Discussion: Blood should be drawn with a steel straight needle instead of an intravenous catheter. However, when that is not possible, we recommend the use of a 20 G intravenous catheter with Luer-Lock access device if a blood sample is to be drawn from intravenous line.

Key words: Emergency department; Hemolysis; Phlebotomy

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Introduction

Most factors that cause erroneous laboratory test results occur in the preanalytical phase.[1] Hemolysis is the major cause of preanalytical errors.[2] Hemolysis is more commonly observed in emergency department specimens than in other hospital departments, and 10% to 30% of emergency department specimens are affected by hemolysis.[3] While blood sample hemolysis affects test results by causing a false decrease in albumin, alkaline phosphatase, and sodium, it also falsely increases alanine aminotransferase, aspartate aminotransferase, lactate dehydrogenase, creatine kinase, and, especially, potassium levels.[2,4] In addition, blood

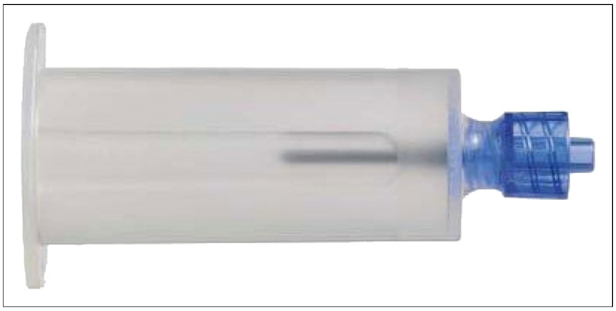

FIGURE
Luer-Lock access device.

sample hemolysis causes positive interference in troponin I tests but false negative results for troponin T.[2] Therefore, many laboratories reject the hemolyzed blood sample and require repeat samples for the affected test. This situation prolongs the results of laboratory tests, causing delays in diagnosis, hospitalization, discharge, and treatment of patients and increasing the length of their stay in the emergency department.[5] In addition, blood sample hemolysis may lead to patient and nurse dissatisfaction.[6,7]

The high rates of blood sample hemolysis in the emergency department have been attributed to the frequent use of intravenous (IV) catheters.[8] However, in order to save time and provide comfort to the patient (by avoiding a second vascular access), in ED practice in our country, when both an IV infusion is to be placed and a blood sample is to be drawn, the blood samples are usually drawn with a syringe from the IV catheter after the vascular access has been placed. This poses risks such as needlestick injuries and blood contamination and increased hemolysis during the transfer of blood from the syringe to the blood tubes.[9] In recent years, blood drawing devices such as S-Monovette tubing (Sarstedt, Nümbrecht, Germany) and Luer-Lock access device (Becton Dickinson, NJ) (Figure) have been used to reduce blood sample hemolysis during phlebotomy from IV catheters.[9,10]

The aim of this study is to determine the rates of hemolysis in phlebotomy methods used in the emergency department and to determine the most appropriate phlebotomy method and device to reduce hemolysis of blood samples in the emergency department.

Methods

This study is a prospective, comparative descriptive study conducted in the Emergency Medicine Clinic of Kırşehir Training and Research Hospital between April 1, 2021, and May 31, 2021. The research involving human subjects was conducted in accordance with all relevant national regulations and institutional policies and was consistent with the principles of Declaration of Helsinki. It was approved by the Ethics Committee of the Faculty of Medicine of Ahi Evran University under number 2021-06/60. Patients were informed verbally about the study, and verbal informed consent was obtained.

SETTING AND SAMPLE

Our hospital is the only hospital in the city center and serves as a tertiary emergency service. The emergency department is visited by an average of 360,000 patients per year, and we have 36 nurses and 30 physicians working in our department. Regardless of their demographic characteristics and comorbidities, patients who presented to the emergency department with any complaint and required blood sampling for testing (biochemistry test) were included in the study. Patients younger than 18 years and patients who had an IV catheter placed by emergency medical services before admission to emergency department were excluded.

GPower 3.1.9.7 (Heinrich-Heine-Universität, Düsseldorf, Germany) program was used to calculate the sample size of the study. The Cohen's effect size ($d = 0.17$) was calculated using data from a similar study in the literature, and the total study group was calculated as a minimum of 573 with a margin of error of 5% and power of 95%.[11]

PROCEDURE

In the study, blood samples were collected from the vein with a steel straight needle or via an IV catheter. Syringes and blood transfer devices (Vacutainer and Luer-Lock access device) were used as phlebotomy devices. The syringe was used for phlebotomy with a steel straight needle as well as for blood drawing from the IV catheter hub. The Vacutainer (Becton Dickinson, NJ) was used for steel straight needle phlebotomy, and the Luer-Lock access device was used for blood drawing from the IV catheter hub. IV catheters with 2 different gauges, 22 G (blue) and 20 G (pink), were used for vascular access. The steel straight needle of syringe and the Vacutainer were 21 G. Accordingly, the patients who participated in the study were divided into 6 groups.

Group 1

Patients whose blood was drawn via steel straight needle using a syringe without establishing vascular access.

Group 2

Patients whose blood was drawn via steel straight needle using a Vacutainer (Holder) without establishing vascular access.

Group 3

Patients whose vascular access was established with a 22 G IV catheter and whose blood was drawn with a syringe.

Group 4

Patients whose vascular access was established with a 22 G IV catheter and whose blood was drawn with the Luer-Lock access device.

Group 5

Patients whose vascular access was established with a 20 G IV catheter and whose blood was drawn with a syringe.

Group 6

Patients whose vascular access was established with a 20 G IV catheter and whose blood was drawn with the Luer-Lock access device.

The study groups were studied sequentially. When one group was completed, the next group took its turn. Patients without exclusion criteria were assigned to the study group of the day by the nurse. Venous blood was collected from all patients who participated in the study. Blood was collected from the antecubital region by 6 nurses with at least 2 years of experience in emergency services. The nurses collecting the blood were previously trained about the study. Data were entered into the study form by the nurses who drew the blood. The study form included information on age, sex, whether vascular access was established, phlebotomy device used, IV gauge, and difficulty level of phlebotomy (easy, medium, difficult). Blood was collected in 5 mL gel serum tubes (BD Vacutainer SST II tube, Becton Dickinson, NJ), which had to be filled completely. Blood collected with the syringe was transferred to the tube by opening the cap. The tubes were sent to the biochemistry laboratory of the hospital by pneumatic system without waiting. The blood, which was allowed to clot in the laboratory for 30 minutes, was centrifuged at 2000 g for 10 minutes, and the serum was separated. The presence of hemolysis in the serum was detected using an autoanalyzer (AU 680; Beckman Coulter Inc, Brea, CA). Laboratory personnel were blinded to the study.

STATISTICAL ANALYSIS

Normality of the data was determined using the Kolmogorov-Smirnov test. Because age, which is a continuous parameter, was not normally distributed, the Kruskal-Wallis test was performed to compare the groups. Then, Dunn's nonparametric comparison was used for post hoc analysis. Chi-square test was used to compare categorical data. Significance was adjusted according to the post hoc Bonferroni method (adjust). Independent predictors of hemolysis were determined using logistic regression analysis. Hosmer-Lemeshow goodness-of-fit statistics were used to assess model fit. Statistical analyses were performed with SPSS for Windows version 21.0 software package (IBM Corp, Armonk, NY). P values of $< .05$ were considered statistically significant.

Results

A total of 715 patients participated in the study. The blood sample hemolysis rate of all samples sent to the laboratory from the emergency department was 25.7%. The median, minimum, and maximum ages of the participants were 49, 18, and 94 years, respectively. The number of male participants in the study was 298 (41.7%). Demographic characteristics and hemolysis rates of blood samples from the groups are summarized in Table 1.

Blood sample hemolysis was more frequent in men than in women (33.6% and 20.1%, respectively, $P < .001$) (Table 1). The lowest blood sample hemolysis rate was found in group 2 and the highest in group 3 (11.2% and 41.8%, respectively) (Table 1). Although hemolysis rates increased with increasing phlebotomy difficulty, there was no statistically significant difference (24.1%, 29.3%, and 36%, respectively).

The hemolysis rate in patients whose blood was drawn with the IV catheter (groups 3, 4, 5, and 6) was statistically significantly higher than in patients whose blood was drawn with a steel straight needle (groups 1 and 2) (32.1% and 17.4%, respectively).

There was no statistically significant difference in the hemolysis rates of patients (between groups 1 and 2) whose blood was drawn with a syringe and a Vacutainer without IV access (23.4% and 11.2%, respectively) (Table 1).

There was no statistically significant difference between the rate of blood sample hemolysis in patients whose blood

TABLE 1
Demographic characteristics and blood sample hemolysis rates of all groups

Variable	Group 1 (*n* = 158) (straight needl e-syringe)	Group 2 (*n* = 152) (straight needle-Vacutainer)	Group 3 (*n* = 98) (22 G IV catheter with syringe)	Group 4 (*n* = 87) (22 G IV catheter with Luer-Lock)	Group 5 (*n* = 112) (20 G IV catheter with syringe)	Group 6 (*n* = 108) (20 G IV catheter with Luer-Lock)	*P* value
Male, n (%)	75 (47.5)*	39 (25.7)*	36 (36.7)*	40 (46)*	60 (53.6)*	48 (44.4)*	< .001
Age, y	42 (31-57)	43 (29-59)	53 (30-71)	50 (33-62)	53 (39-70)	57 (41-71)	< .001
Hemolysis, n (%)	37 (23.4)*	17 (11.2)*	41 (41.8)*	28 (32.2)*	44 (39.3)*	17 (15.7)*	< .001

Age values are presented as median (25th and 75th percentiles).
The different symbols in the Table denote groups that do not differ post hoc in each column.
IV, intravenous; G, gauge.
* Indicates no statistically significant difference between the values in the groups of the same lines.

was drawn through a 22 G catheter with a syringe and with a Luer-Lock access device (41.8% and 32.2%, respectively). The rate of blood sample hemolysis in patients whose blood was drawn through a 20 G catheter with a Luer-Lock access device was statistically significantly lower than in patients whose blood was drawn with a syringe (15.7% and 39.3%, respectively) (Table 1).

The logistic regression analysis performed to determine the risk factors affecting blood sample hemolysis rates is summarized in Table 2. The result of the logistic regression analysis was that phlebotomy with Vacutainer without vascular access reduces the risk of hemolysis by approximately half compared with syringe (odds ratio [OR] = 0.47, *P* = .02). Phlebotomy through a 22 G catheter with a syringe statistically significantly increased the risk of hemolysis (OR = 2.64). Although phlebotomy with a Luer-Lock access device increased the risk of hemolysis (OR = 1.72), it was not statistically significant. Although phlebotomy via a 20 G catheter with Luer-Lock access decreased the risk of hemolysis, it was not statistically significant. Phlebotomy with a syringe statistically significantly increased the risk of hemolysis (OR = 2.20). According to logistic regression analysis, male sex statistically significantly increased the risk of hemolysis (OR = 1.92). According to the difficulty level of phlebotomy, difficult phlebotomy statistically significantly increases the risk of hemolysis (OR = 2.53).

Discussion

The literature reports a particularly high incidence of hemolysis (6%-30%) in ED blood samples.[8,12,13] In our study, the rate of hemolysis in ED blood samples was 25.7%, which is consistent with the literature. In our study, male sex and difficult phlebotomy were found to significantly increase the risk of blood sample hemolysis. Nevertheless, there is a contradiction in the literature between studies investigating the association between age, phlebotomy difficulty, and hemolysis.[8,14-16]

TABLE 2
Logistic regression analysis to estimate the probability of blood sample hemolysis

Risk factor	OR (95% CI)	*P* value
Syringe		< .001
Vacutainer (holder)	0.47 (0.25-0.88)	.02
Syringe with 22 G catheter	2.64 (1.50-4.63)	.01
Luer-Lock with 22 G catheter	1.72 (0.94-3.12)	.08
Syringe with 20 G catheter	2.20 (1.28-3.80)	.01
Luer-Lock with 20 G catheter	0.68 (0.35-1.31)	.25
Age	1.00 (0.99-1.01)	.93
Sex (male)	1.92 (1.34-2.76)	< .001
Degree of difficulty (easy)		.06
Degree of difficulty (medium)	1.39 (0.91-2.12)	.12
Degree of difficulty (difficult)	2.53 (1.02-6.26)	.05

R^2 = 0.09 (Cox and Snell), 0.13 (Nagelkerke).
Model χ^2 = 67.665 (df = 7), *P* < .001.
CI, confidence interval; OR, odds ratio; G, gauge.

Similar to previous research studies, we found that blood sample hemolysis rates were significantly higher in blood samples collected with an IV catheter than with a steel straight needle.[8,17,18] Some studies have found that the use of evacuated tube systems compared with a syringe is associated with higher blood sample hemolysis rates when blood is drawn with a straight needle as the method of phlebotomy.[16,19] However, in another study, it was found that the use of a syringe was found to cause a higher rate of blood sample hemolysis compared with evacuated tube systems.[20] In our study, we found that phlebotomy with the Vacutainer without IV access reduced the risk of hemolysis by about half compared with the syringe.

Researchers found that phlebotomy with the vacuum system, especially from IV catheters, increases hemolysis compared with manual aspiration.[9,13,21] It was found that blood sample hemolysis rates were higher when blood was collected from the IV catheter in the emergency department using the Luer-Lock access device compared with aspiration using the S-Monovette tube but lower than routine (aspiration using the syringe).[10] In addition to studies reporting that a decrease in catheter diameter results in a significant increase in hemolysis rates in blood samples, there are also studies reporting that there is no significant relationship between catheter diameter and blood sample hemolysis.[4,11,19,22] In our study, phlebotomy with a syringe was found to increase the risk of hemolysis in both 20 G and 22 G IV catheters. Phlebotomy via a 22 G IV catheter with Luer-Lock access device increased the risk of hemolysis, whereas phlebotomy via a 20 G IV catheter decreased the risk of hemolysis.

Limitations

The main limitation of our study is that it is a single-center study. The other limitation is the use of only 22 G and 20 G IV catheters in patients with IV access. In addition, the different age and sex distribution between the study groups could be considered a limitation of the study. Further studies are needed to investigate the effects of different catheter diameters on blood sample hemolysis outcomes.

Implications for Emergency Nurses

Blood sample hemolysis is a prevalent condition in emergency departments. Hemolysis leads to false results, repetitive blood draws, delays in diagnosis, and patients' prolonged stay in the emergency department, and this extra time causes patient and nurse dissatisfaction. Drawing blood through intravenous catheters in the emergency department increases the rate of hemolysis. In this large-sample study, the effects of different blood drawing methods and devices on blood sample hemolysis were compared. Blood drawing through a steel straight needle is the best method to reduce blood sample hemolysis. In cases in which drawing blood through the intravenous catheter is required, the utilization of a 20 G catheter and a Luer-Lock access device together reduces the rates of hemolysis and thus prevents its undesirable consequences.

Conclusion

According to the results of our study, phlebotomy with steel straight needles (especially the use of a holder) reduces blood sample hemolysis in the emergency department. Therefore, it is recommended that nurses consider obtaining blood samples with steel straight needles separately from the placement of the IV catheter. However, when that is not possible, we recommend phlebotomy from a 20 G IV catheter with a Luer-Lock access device in cases where phlebotomy via vascular access is required in the emergency department. We think that the result of this study may be important in terms of suggesting an alternative technique to reduce the hemolysis that occurs when blood is drawn from the IV catheter, which is an important problem in emergency services. In this regard, there is a need for studies with different catheter diameters and phlebotomy devices.

Data, Code, and Research Materials Availability

An ethics approval was obtained for this study from the ethics committee of Ahi Evran University Faculty of Medicine (Approval numbered 2021-06/60 and approval date 23.03.2021).

Author Disclosures

Conflicts of interest: none to report.

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