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Research Article

Improving Phlebotomy Practices Through Small-Volume Blood Tubes: A Survey-Based Study

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Abstract

Aim: The blood collection for laboratory tests has been frequently performed due to evidence-based medicine. We aimed to conduct a survey on phlebotomy among phlebotomists and patients and to reduce unnecessary blood loss by using small-volume blood collection tubes.

Material and Method: A survey among phlebotomists and patients was conducted to gather their opinions. Phlebotomists received training on the importance of the preanalytical process. The blood volume required for laboratory tests was reduced by 33.3%-50.0% in children and adults, and 63.0%-84.0% in newborns. Following this intervention, we investigated its effects on the blood transfusion ratio in the neonatal and adult intensive care unit (NICU and ICU) and the amount of laboratory medical waste generated.

Results: A majority of phlebotomists (91.8%) reported difficulties in drawing blood from newborns, pediatric, oncology, hematology, and geriatric patients. Additionally, 68.9% of phlebotomists and 57.1% of patients expressed an opinion for reduced blood volume. Despite an increase in the number of laboratory tests (28.4%) and samples (15.7%), we observed a 17.8% reduction in the amount of laboratory medical waste. Although the number of patients in NICU increased statistically significant, the increase in transfusion rates was not significant. Although the number of patients in ICU increased, transfusion rates decreased, but neither was found to be statistically significant.

Conclusion: Post-graduation, phlebotomists should be educated regularly about the preanalytical process. Based on the opinions of both phlebotomists and patients, using small-volume tubes in patients with difficult blood collection may increase their satisfaction. Generally, laboratory medical waste may be reduced.

Keywords: Laboratory testing, blood collection tube, iatrogenic anemia, patient satisfaction, personnel satisfaction, laboratory medical waste

INTRODUCTION

Patient Blood Management (PCM) is a multidisciplinary diagnostic and therapeutic approach that focuses on the rational use of blood components, reducing unnecessary blood loss. Minimizing iatrogenic blood loss is an important part of PBM (1). The most common cause of iatrogenic anemia is recurrent blood draws for laboratory tests (2,3). Iatrogenic anemia is frequently seen in intensive care unit (ICU) patients (4). On the second day of admission to the ICU, more than 70% of adults have anemia and more than half of them require a blood transfusion (5). In the neonatal intensive care unit (NICU), the low body weight of patients exacerbates iatrogenic anemia. It is estimated that 15-30% of blood volumes are lost due to blood draw during the first six weeks of an infant's life in the NICU (6).

Minimum pipetted serum/dead volume should be 1-35 µL/100-500 µL, plasma/dead volume 10-50 µL/200 µL or whole blood/dead volume 40-80 µL/200 µL for each test in our laboratory. According to these data, it is thought that blood is drawn more than the required blood volumes to be analyzed. It has been reported that only 9% of blood in standard blood collection tubes is used for laboratory tests (7). Laboratories accredited by the College of American Pathologists recorded blood collection tube size/volume and analytic/discard volume for complete blood cell count and electrolyte panel in ICU patients (8). The 2.76 mL of blood was more than the analytic volume of complete blood cell counts, and 1.75 mL of blood was

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more than the analytic volume of routine electrolytes. The discard volume was 2.84 mL per tube for complete blood cell counts and 2.02 mL per tube for electrolyte panels. Specimen collection tube size was directly associated with overcollections and discard volumes (8).

Recently, microtubes (small-volume tubes) pre-assembled with carrier tubes (13x75 mm) can be included in the autoanalyzer without manual process, and thus laboratory worker safety can be increased.

For this purpose, the phlebotomist was trained on the importance of phlebotomy in preanalytical processes and its contribution to PBM in order to reduce unnecessary blood loss and to popularize small-volume blood collection tubes. A survey of the employees and patients was conducted regarding their experiences and opinions regarding phlebotomy. In accordance with their opinions, the blood collection volume for laboratory tests was reduced in our hospital. The effects of this intervention on the blood transfusion ratio in ICU/NICU and the amount of laboratory medical waste were evaluated.

MATERIAL AND METHOD

Local ethical approval was obtained (the date/number of decision, 29.12.2021/468) and subjects gave informed consent.

Training and Survey of Phlebotomists

In January 2022, phlebotomists (n=388) who draw blood in our hospital were trained by a biochemistry specialist on preanalytical processes, especially blood collection tube volume and filling ratio, and a survey was conducted. The personnel's experience with phlebotomy in the 1st and 2nd questions and the knowledge on phlebotomy in the 3rd and 4th questions were evaluated. In the 5th question, the opinion of the personnel on the blood collection volume was asked.

Survey of Patients

In January 2022, adult and pediatric patients were surveyed on phlebotomy in outpatient and inpatient clinics. The survey was conducted with the help of parents or relatives of pediatric patients. In the 1st, 2nd and 3rd questions, the patient's experience with phlebotomy was evaluated. In the 4th and 5th questions, the opinion of the patient on the blood collection volume was asked. Blood test to be "once a week and once a month" was accepted as "often", "once or twice a year" as "sometimes" and "other" as "rarely".

Reducing the Blood Collection Volume for Phlebotomy

In January 2022, the blood volumes required to be drawn from newborn, pediatric and adult patients for laboratory tests were reduced at a certain ratio in our hospital (Table 1). Sedimentation, blood type test, crossmatch test and blood gas analysis were excluded. Venous blood samples were taken into 1.0 mL (MiniCollect® Complete, 9NC Sodium Citrate 3.2%, 13x75 mm, GBO GmbH, Austria), 2.5 and 5.0 mL tubes (Vacusera®, Serum Gel and Clot Activator, 13x75 mm, Diseara, İzmir, Türkiye). Capillary blood samples were taken into 0.8 mL (MiniCollect® Complete, CAT Serum Seperator, 13x75 mm, GBO GmbH, Austria) and 0.5 mL (MiniCollect® Complete, K2E/K2EDTA, 13x75 mm, GBO GmbH, Austria) tubes.

Table 1. Blood volumes to be drawn in neonatal, pediatric and adult patients

Laboratory tests	2021	2022	Reduced rate of blood volume (%)
Blood volumes to be drawn in pediatric and adult patients			
Biochemical tests	5.0 mL	2.5 mL	50.0
Hormonal tests	5.0 mL	2.5 mL	50.0
Coagulation tests	2.7 mL	1.8 mL	33.3
Serological tests	5.0 mL	2.5 mL	50.0
Blood volumes to be drawn in neonatal patients			
Biochemical tests	5.0 mL	0.8 mL	84.0
Hormonal tests	5.0 mL	0.8 mL	84.0
Coagulation tests	2.7 mL	1.0 mL	63.0
Serological tests	5.0 mL	0.8 mL	84.0
Complete blood count	2.0 mL	0.5 mL	75.0
Hemoglobin A1c	2.0 mL	0.5 mL	75.0

The quality indicators through twelve months in 2021 and 2022 years [the number of laboratory tests and samples, the amount of laboratory medical waste, the number of patients hospitalized in NICU/ICU, the number of erythrocyte transfusions (ET) (unit) per patient and the ratio of patients transfused in NICU/ICU] were obtained from the hospital information system. Laboratory medical wastes included blood collection tubes, gloves, cultures, urine containers and cuvettes in microbiology and biochemistry laboratory.

Statistical Analysis

Minitab software (version 15.1.20.0; Minitab, Inc., State College, PA) was used for statistical analysis. The mean and standard deviation or median and interquartile range of data for quality indicators in the years 2021 and 2022 were calculated. The percentage change between 2021 and 2022 was calculated using the formula: 100*(average of 2022 - average of 2021) / average of 2021. The difference in averages over twelve months between 2021 and 2022

years was analyzed by the Wilcoxon test. In addition, the relationship between the answers to the survey was analyzed by the Chi-Square test. p<0.05 was considered statistically significant.

RESULTS

Evaluation of the Survey Conducted to Phlebotomist

62.9% (n=244) of phlebotomists who trained participated in the survey. Demographic characteristics and questions/answers of the phlebotomist are presented in Table 2. Phlebotomists were mostly nurses (68.0%) and female (89.8%), and had a license degree (86.9%). The mean age of phlebotomists was 35.4±9.5.

91.8% of the phlebotomists had difficulty drawing blood from newborn, pediatric, oncology, hematology and geriatric patients (Question 1). Only 30.8% of personnel who had difficulty drawing blood from these patients and 45.0% of those who had no difficulty were able to fully fill the blood collection tubes (p=0.060). 70.1% of personnel who had difficulty drawing blood and 55.5% of those who had no difficulty preferred to reduce the amount or volume of blood collected (p=0.156).

88.9% of the phlebotomists draw the necessary amount of blood into blood collection tubes with gel (Question 3). In addition, 77.5% of the personnel could fill the necessary blood in the collection tubes including anticoagulants (Question 4). The personnel want to reduce the amount/volume of blood was 68.9% (Question 5).

Table 2. Demographic characteristics and questions/answers in survey of health personnel (n=244)

Demographic characteristics		
Age, mean±standard deviation	**35.4±9.5**	**n (%)**
Gender, n (%)	Female	219 (89.8)
	Male	25 (10.2)
Position, n (%)	Nurse	166 (68.0)
	Trainee Nurse	33 (13.5)
	Midwife	31 (12.7)
	Laboratory technician	14 (5.7)
Workplace, n (%)	Adult inpatient service	110 (45.1)
	Adult intensive care	54 (22.1)
	Emergency room	23 (9.4)
	Pediatric outpatient service	22 (9.0)
	Adult outpatient service	21 (8.6)
	Blood collection unit	14 (5.7)
Education, n (%)	License degree	212 (86.9)
	Associate degree	23 (9.4)
	High school	9 (3.7)
Questions	**Answers**	**n (%)**
1. Which patients do you have difficulty drawing blood?	Newborn, pediatric, oncology, haematology, or geriatric patients	224 (91.8)
	None	20 (8.2)
2. Can you fill the blood collection tubes completely if you have difficulty drawing blood?	Yes	78 (32.0)
	Partially	151 (61.9)
	No	15 (6.1)
3. Is it necessary to draw the recommended amount of blood in blood collection tubes with gel?	Yes	217 (88.9)
	No idea	20 (8.2)
	No	7 (2.9)
4. Do you pay attention to the drawn blood amount into blood tubes with anticoagulants?	I pay attention	189 (77.5)
	I ignore it if I have difficulty drawing blood in some patients	54 (22.1)
	I don't pay attention	1 (4.0)
5. Would you like the amount/volume of blood drawn into each tube to be reduced?	Yes	168 (68.9)
	It doesn't matter	46 (18.9)
	No	30 (12.3)

Evaluation of the Survey Conducted to the Patients

Demographic characteristics and questions/answers of the patients (n=140) are presented in Table 3. 34.8% of patients with chronic diseases and 13.8% of those without chronic diseases had blood tests "often" (p<0.05). 26.6% of adult patients have frequent blood testing, while only 15.8% of pediatric patients stated that they do (p<0.05) (Question 1). The ratio of difficult blood collection in adult patients was 34.1%, while this ratio (55.2%) was higher in children (p<0.05) (Question 3). The blood drawing in adult inpatients was more difficult than in outpatients (48.0% vs. 12.8%, p<0.05) and in pediatric inpatients more difficult than outpatients (16.0% vs. 53.8%, p<0.05) (Question 3). The ratio of pediatric inpatients, who stated that the blood volume is excessive, had higher compared to those of outpatients (42.3% vs. 16.0%, p<0.05). Similarly, the ratio of adult inpatients, who stated that the blood volume is excessive, had higher compared to those of outpatients (32.0 vs. 10.3%, p<0.05) (Question 4).

37.3% of the patients who do not think the drawing blood volume was excessive and 90.3% of the patients who think it was excessive, wanted to reduce blood volume (p<0.001) (Question 5).

Table 3. Demographic characteristics and survey of patients

Demographic characteristics		**n (%)**
Clinics	Pediatric blood collection unit	50 (35.7)
	Child inpatient service unit	26 (18.6)
	Adult blood collection unit	39 (27.9)
	Adult inpatient service unit	25 (17.9)
Age group	Pediatric	76 (54.3)
	Adult	64 (45.7)
Age, mean±standard deviation	Pediatric	6.6±5.2
	Adult	55.6±17.6
Gender	Female	67 (47.9)
	Male	73 (52.1)
Chronic disease	Yes	46 (32.9)
	No	94 (67.1)
Questions	**Answers**	**n (%)**
1. How often do you have blood tests?	Often	29 (20.7)
	Sometimes	83 (59.3)
	Rarely	28 (20.0)
2. How many blood collection tubes are used when you have a blood test?	1-2	55 (39.3)
	3-4	70 (50.0)
	5 or more	7 (5.0)
	I don't know	8 (5.7)
3. Has the health personnel difficulty drawn blood from you?	Yes	39 (27.9)
	Sometimes	25 (17.9)
	No	76 (54.3)
4. Do you think the amount/volume of blood drawn from you was excessive?	Yes	31 (22.1)
	Partially	26 (18.6)
	No	83 (59.3)
5. If less blood was needed for lab tests, would you like to reduce the amount/volume of blood drawn?	Yes	80 (57.1)
	Doesn't matter	35 (29.3)
	No	17 (13.6)

Effect on Quality Indicators of Reduced the Blood Collection Volume

Compared to the pre-intervention, the blood volume needed from each patient for laboratory tests was reduced by 33.3%-50.0% in pediatric and adult patients, and by 63.0%-84.0% in newborn patients.

The quality indicators of hospital for 2021 and 2022 years are shown in Table 4. Although there was an increase in the number of samples (15.7%) and tests (28.4%) in the laboratory in 2022, a decrease (17.8%) was found in the amount of laboratory medical waste. However, the cost of laboratory medical waste increased by 47.6%. While there was an increase in the number of patients hospitalized in the NICU, no significant increase was found in the ICU. No statistically significant change was observed in the amount of ET (unit) per patient and the ratio of patients transfused in the ICU/NICU.

Table 4. Quality indicators of hospital in 2021 and 2022 years

Indicators	2021 Mean±SD Median (IQ)	2022 Mean±SD Median (IQ)	Change (%)	P value
The number of laboratory tests (n)	363,354±62,036 384,200 (307,572-412,640)	466,514±60,119 456,722 (424,458-517,920)	28.4	**0.002**
The number of laboratory samples (n)	133,118±19,732 139,698 (116,440-147,124)	154,013±15,645 154,294 (143,823-162,610)	15.7	**0.004**
The amount of laboratory waste (kilogram)	1,903±164 1,933 (1,779-2,014)	1,564±284 1,531 (1,350-1,741)	-17.8	**0.005**
The cost of laboratory waste (TL)	5,899±509 5,992 (5,514-6,247)	8,710±1,773 8,647 (7,102-9,908)	47.6	**0.002**
The number of patients in ICU (n)	267±21 265 (256-274)	272±27 283 (246-292)	1.87	0.505
The number of patients in NICU (n)	49.8±10.1 45.5 (44.0-57.2)	63.3±7.4 66.0 (55.5-70.0)	27.1	**0.021**
The number of erythrocyte transfusions (ET) per patient (unit) in ICU	2.80±0.41 2.72 (2.46-3.09)	2.62±0.32 2.61 (2.36-2.87)	-7.42	0.530
The number of erythrocyte transfusions (ET) per patient (unit) in NICU	0.92±0.91 1.00 (0-1.92)	1.71±1.25 1.50 (1.00-2.36)	85.9	0.194
The ratio of patients transfused in ICU (%)	23.4±3.2 22.0 (21.3-26.5)	22.7±4.6 23.2 (19.0-26.2)	-2.99	0.754
The ratio of patients transfused in NICU (%)	2.32±2.59 1.85 (0-4.38)	3.12±1.39 3.21 (2.87-3.69)	34.5	0.388

ET: erythrocyte transfusion, ICU: adult intensive care unit, IQ: interquartile, NICU: neonatal intensive care unit, SD: standard deviation, TL: Turkish lira

DISCUSSION

To the best of our knowledge, our study is the only research in which phlebotomists and patients were surveyed about blood collection and tube volume. According to the survey of phlebotomists, it was determined that most of them had difficulty drawing blood in newborn, pediatric, oncology, hematology or geriatric patients. Based on the answers to the 3rd and 4th questions, it was concluded that the majority of personnel do not lack knowledge. However, while most phlebotomists demonstrated attention and sufficient knowledge regarding tube blood-filling volume, it doesn't necessarily guarantee their ability to consistently fill the tubes to the desired blood volume. When compared to personnel without difficulty, those who had difficulty drawing blood had a lower rate of fully filling the blood collection tubes and a higher rate of wanting a reduction in the blood volume. Therefore, small-volume tubes can enhance personnel satisfaction when working with neonatal, pediatric, oncology, hematology, or geriatric patients.

According to the survey conducted on our patients, blood draws were frequently performed in adults and patients with chronic diseases. It was stated that blood collection was more difficult in pediatric patients. Both adult and pediatric inpatients compared to outpatients stated that blood was drawn with more difficulty and excessive volume.

59.3% of the patients did not find the drawn blood volume excessive, and 54.3% of the patients did not experience difficulty during blood draws. The patients' responses made the researchers consider that these patients might not have clear information about the effects of phlebotomy. Patients readily accepted the amount of blood to be drawn for laboratory tests without a doubt. However, most patients with a high awareness of blood collection volume preferred a reduction in blood volume compared to those who were not as aware (90.3% vs. 37.3%, respectively).

We aimed to improve preanalytical processes by training personnel in our hospital and to contribute to PBM and laboratory waste management by using small-volume blood collection tubes based on the opinions of both patients and personnel. Reduced blood volumes (specific percentages mentioned) were found to be sufficient for various types of tests, and the results could be reliably produced with less blood volume without requiring changes in laboratory processes. Adequate serum and plasma levels were available for additional tests due to the request of clinicians or repeated tests due to various reasons, such as analytical errors or device malfunctions. Much of the blood drawn for laboratory tests is discarded. Sanchez-Giron et al. found that 91% of blood in standard-volume tubes remained and 74% of blood in small-volume tubes remained when the analysis was completed (7).

About 25.0% of total medical waste in hospitals (including cafeterias, operating rooms, laboratories, emergency rooms, ambulance service and facilities) and 27.8%

of total disposable cost have been produced from laboratories (9). It was stated that most of the plastic wastes in hospital laboratories were blood collection tubes (70.0%) and gloves/lab wares (20.0%). Thus, in our study, other laboratory medical wastes such as cultures, gloves, urine containers and cuvettes were regretted. Although the number of laboratory tests (28.4%) and samples (15.7%) increased, it was determined that the amount of medical waste significantly decreased (17.8%). Although the average unit cost of medical waste in our laboratory increased by 80.6%, the increase in monthly cost was less (47.6%). Additionally, the phlebotomy tubes used can cause huge environmental impacts (10). All the plastic waste from phlebotomy tubes can't be recycled and must be incinerated, causing additional emissions of greenhouse gases and pollution (11). The use of one-size smaller tubes for pediatric and adult patients may reduce the amount of hazardous waste, and simplify the purchase and storage of tubes (8).

Systematic research conducted in 2022 showed that the use of pediatric-sized blood collection tubes in adult intensive care patients can significantly reduce the daily blood drawn (12). Using small-volume tubes reduced blood loss by 73%, the risk of severe anemia (hemoglobin <7.0 g/dL) by more than half, and the unit of packed red blood cells transfused per patient by 27% (7,13,14). Foulke et al. found that blood loss was reduced by 33%, and the percentage of patients who had at least one transfusion was reduced by 10% after using small-volumes (pediatric phlebotomy tubes, reduced syringe volumes) for the laboratory tests (15). It has been stated that the daily reported losses from blood sampling may contribute to post-operative hemoglobin fall resulting in blood transfusion (16). Matzek et al. have stated that hemoglobin concentrations declined with the intensity of phlebotomy during hospitalization in the ICU and each 100 mL of phlebotomy volume during hospitalization was associated with an increase of 1.15 multiplied in red blood cell units transfused (17).

Despite a statistically significant increase in the number of patients hospitalized in the NICU, there was no statistically significant increase in the ratio of transfused patients and the number of ET (unit) per patient. Before the use of small-blood volume tubes, blood gas analysis by capillary tube or non-invasive measurements has already been preferred for parameters such as glucose, creatinine, electrolytes, bilirubin, hemoglobin, and lactate. Although the number of patients hospitalized in the ICU increased, the ratio of transfused patients and the number of ET (unit) per patient decreased. However, these changes were not statistically significant. As a limitation of our study, transfusion indications for intensive care patients were not considered. We did not have information on when the transfusions occurred, and the frequency and amount of phlebotomy on days following the patient's hospitalization. It may be possible to reveal its effect on transfusion rates with further studies that include clinical diagnosis and follow-up information of the patients.

Small-volume blood collection tubes, point-of-care tests, closed sampling systems, capillary samples, and noninvasive analysis methods can be preferred to improve preanalytical processes and reduce iatrogenic anemia caused by phlebotomy. Integrated systems that can run multiple tests on a single blood sample can be used. Training can be given to phlebotomists and clinicians on reducing test requests and on blood collection techniques that reduce blood loss. Local governments can develop hospital quality indicators and policies on practices that reduce blood loss.

CONCLUSION

As a result, to improve preanalytical processes and reduce iatrogenic anemia and the amount/cost of laboratory waste, small-volume blood collection tubes can be preferred. As an alternative to small-volume blood collection tubes, point-of-care tests closed blood sampling systems, capillary samples, noninvasive analysis methods, and integrated systems that can run multiple tests on a single blood sample can be used. Training can be given to phlebotomists and clinicians on reducing test requests and on blood collection techniques that reduce blood loss. Local governments can develop hospital quality indicators and policies on practices that reduce blood loss.

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