Turkish Journal of Clinics and Laboratory

To cite article: Aydın Ö, Göl G, Gönen Dede F, Akın D. Investigation of blood collection errors in the preanalytical process. Turk Clin Lab 2017;8(4):146-151.

Original Article

Investigation of blood collection errors in the preanalytical process

Preanalitik süreçte kan alma hatalarının incelenmesi

Özlem AYDIN[1*] Gülnihan GÖL[2], Füsun GÖNEN DEDE[1], Dilek AKIN[3]

[1]Eskisehir Yunus Emre Government Hospital, Department of Quality Management, Eskisehir,
[2]Eskisehir Yunus Emre Government Hospital, Department of Management, Eskisehir,
[3]Eskisehir Yunus Emre Government Hospital, Department of Statistic, Eskisehir, TURKEY

ABSTRACT

Aim: Sample collection errors, in which the human factor plays an active role, depend on the experience and personal characteristics of the blood-drawing person. This study aimed to investigate blood collection errors and to compare the rates of pre-analytical errors in blood samples of outpatients and inpatients in our hospital.

Material and Method: Pre-analytical errors were determined by examining rejected samples from the Laboratory Information System records for a period of 10 months. The samples were separated into working groups and pre-analytical error groups. The daily number of sampling procedures was calculated for each nurse working in the blood collection unit.

Results: The total rate of rejected samples was 0.2% in outpatients and 1.23% in inpatients (P = 0.000). Nurses working in the blood collection unit drew about 200 blood samples each per day. Clotted samples and insufficient volume were the most often found causes for rejection of samples.

Conclusion: Most preanalytical errors can be reduced by appropriate training of phlebotomists and nurses. Practical blood draw training can be included in the training program of nurses new starting to work in hospital. The reduction of preanalytical errors will contribute to patient safety.

Keywords: Blood sample collection, education, experience, nurse, pre-analytical errors

Corresponding Author*: Özlem AYDIN, Eskisehir Yunus Emre Government Hospital, Department of Quality Management, Eskisehir, TURKEY
e-mail: ozlem.aydn@gmail.com
Phone: 00902222119595-5034
Doi. 10.18663/tjcl.292502
Received 16.02.2017 accepted 24.04.2017

Öz

Amaç: İnsan faktörünün aktif rol oynadığı numune toplama hataları, kan alan kişinin kişisel özellikleri ve deneyimine bağlıdır. Bu çalışmada, hastanemizde yatan hastalar ile ayaktan hastaların kan örneklerindeki preanalitik hata oranlarının karşılaştırılması ve kan toplama hatalarının incelemesi amaçlanmıştır.

Gereç ve Yöntem: Preanalitik hatalar, Laboratuvar Bilgi Sistemi'ndeki 10 aylık periyoda ait reddedilen numune kayıtlarının incelenmesiyle belirlendi. Bu numuneler, çalışma gruplarına ve preanalitik hata gruplarına ayrıldı. Kan alma ünitesinde çalışan her bir hemşirenin günlük numune alma sayısı hesaplandı.

Bulgular: Reddedilen total numune oranı yatan hastalarda %1,23 ve ayaktan hastalarda %0,2 (P = 0.000)'ydi. Kan alma ünitesinde çalışan bir hemşirenin günlük aldığı kan numunesi sayısı, yaklaşık olarak 200'dü. Pıhtılı numune ve yetersiz hacim en sık numune ret sebepleri olarak bulundu.

Sonuçlar: Preanalitik hataların çoğu, flebotomistlerin ve hemşirelerin uygun şekilde eğitilmeleri ile azaltılabilir. Hastanede çalışmaya yeni başlayan hemşirelerin eğitim programına uygulamalı kan alma eğitimi dahil edilebilir. Preanalitik hataların azalması hasta güvenliğine katkıda bulunacaktır.

Anahtar Kelimeler: Kan örneği toplama, eğitim, deneyim, hemşire, preanalitik hatalar

Introduction

Laboratory test results play a key role in health care and have an important influence on clinical decisions [1,2]. Errors that are seen in laboratory testing processes are some of the potential sources of medical errors. Moreover, these errors can potentially affect patient safety, as do other medical errors [2]. Laboratory errors are classified as errors of the preanalytical, analytical and post-analytical phases [3,4]. The preanalytical phase is defined as the process from test ordering by clinicians to the beginning of the laboratory analysis. In this phase, 60–70% of all errors occurring in the laboratory are observed [3,5,6]. The preanalytical phase is complex, after many of these steps are out of the laboratory's control [7,8]. Preanalytical errors occur at any stage of the preanalytical phase, such as patient preparation, sample collection, transportation, and preparation for analysis and storage [9,10]. Because these errors are related to manual activities during the pre-analytical phase, the human factor is important [2]. Errors observed during sample collection stage such as wrong/missing identification, wrong container or tube, insufficient or excess sample volume and insufficient mixing occur at different rates [11,12]. Sample collection stage is one of the preanalytical variables that can be controlled and proper approaches could be developed for minimum errors in this stage [13].

In this study, we focused on errors during sample collection because they are due to manual activities and may depend on blood collection experience. Melkie et al. [14] reported that laboratory professionals (in outpatient departments) have more desirable experiences than non-laboratory professionals (mostly in inpatient departments) in specimen transfer and specimen mixing. Atay et al. [15] reported that personal impact on specimen collection was an important factor; the pre-analytical error rate was 2 to 4 times higher for non-laboratory phlebotomists than for laboratory staff.

Phlebotomy is performed by different healthcare specialists, such as specialized phlebotomists, laboratory technicians, junior medical doctors and nurses, in different countries throughout Europe. However, nurses are most often responsible for performing phlebotomy for hospital inpatients [16]. Nurses are also primarily responsible for collecting blood samples in Turkey [17]. In our hospital, drawing blood in both outpatients and inpatients is performed by nurses as well.

It was aimed to investigate blood collection errors and to determine the pre-analytical error rates and to compare these error rates in the blood samples of outpatients and inpatients. Also, the average number of blood samples drawn daily by each nurse working in the blood collection unit for outpatients was calculated.

Material and Method

The study was performed for a period of 10 months from January 1st 2015 to October 31 2015 in our hospital. Blood samples sent to the central laboratory from inpatient services and the blood collection unit was included in the study. Rejected samples were identified by searching for rejection reasons in the hospital information system. Sample rejection or acceptance criteria are described in the laboratory test guide.

Volume 8 Number 4 p: 146-151

Specimen rejection criteria of the central laboratory were given Table 1. All nurses are provided with this information. In the central laboratory, blood samples are visually evaluated by laboratory technicians for the following criteria, before being rejected. Pre-analytical error groups were categorized as clotted samples (in citrated and EDTA tubes), hemolytic samples, lipemic samples, insufficient volume, excess volume, wrong sample, unsuitable tube, empty tube, without barcodes or unsuitable barcodes (barcode error), delayed transport time, and tube breakage/loss (as defined in the hospital information system). Working groups were categorized as biochemistry, hormones, hematology, sedimentation rate, coagulation, serology and ELISA, as defined in the laboratory information system. In our hospital, sodium citrate tubes (3.2%) are used for coagulation tests, gel separator clot activator tubes for biochemistry tests (i.e. metabolites, enzymes, electrolytes, lipids), hormone assays (immunoassays such as thyroid function tests, fertility hormones, tumor markers), ELISA (i.e. hepatitis markers, HIV test) and serology tests (i.e. C-reactive protein, rheumatoid factor, IgE), K2EDTA tubes for hematology tests (VACUETTE®, Greiner Bio-One GmbH, Kremsmünster, Austria), and sodium citrate tubes (0.13 M, 1.6 ml) for sedimentation rates (ESR) (Vacuum Plus, Sunmax Co., Ltd. Seoul, Korea). During the study was used the blood tubes of same manufacturers in blood drawing from the outpatients and the inpatients.

Table 1. The specimen rejection criteria of the central laboratory.
Improper test requests (incomplete, errors in test input, inconsistent information)
Specimens without barcodes or unsuitable barcodes
Misidentification (unlabeled, mislabeled or mismatched samples)
Improper container or tube
Insufficient or excess specimen volume
Broken tubes or spilled specimen
Hemolyzed specimen
Clotted samples
Lipemic specimen
Inappropriate transport (transport temperature, light exposure, delayed transport time)
Incorrect preservation, storage

Total pre-analytical error rates were determined. Pre-analytical errors were classified into three groups: sample collection errors, inappropriate transport errors and rejection at laboratory reception process; these three groups were then divided into subgroups according to the rejection reasons. The number of daily samplings of each nurse working in the blood collection unit was also counted. Ten nurses were working in the blood collection unit during the study period. As of January 2015 on, 6 of the 10 nurses had been working for 3 to 5 years in the unit. Two nurses had started working in the unit 1 year ago, and the other two nurses 5 months ago. The data were analyzed with Minitab 15 statistical package program. Chi-square test was used for data comparison. Fisher's exact test was used for small samples. A p value <0.05 was considered statistically significant

Results

Total pre-analytical errors were found in 1.23% of all the blood samples of inpatient services and 0.2% ($P < 0.05$) in blood samples of outpatients. The distribution of pre-analytical errors according to working groups is given in Table 2. Error rates in the inpatients and outpatients, and statistical significance of error rates of the pre-analytical groups and working groups are given in Table 2. Rejection rates of pre-analytical error groups, except empty container/tube and broken/lost tube subgroups, were significantly higher in samples of inpatients. The error of clotted samples was higher in the sedimentation rate and coagulation groups of both inpatients and outpatients than in the hematology group. Inpatient sample rejection rates were higher for all working groups except the hormone group. Error rates as a percent of total pre-analytical errors of the working groups were determined in the samples of inpatients and outpatients The group with the highest number of errors is the hematology group in inpatients (33.33% of all errors) and the sedimentation rate group in outpatients (57.83% of all errors) (Table 2).

The samples of hematology (33.33%), sedimentation rate (32.93%) and coagulation (25.54%) were higher in inpatients, while the samples of sedimentation rate (57.83%), coagulation (25.52%) and hematology (13.38%) were higher in the outpatients, respectively (Table 2). Most rejection rates were observed in the sample collection stage (Table 2). Clotted samples have the highest rejection rate in both inpatients and outpatients (Table 2).

Regarding the numbers of samples taken, approximately 200 blood samples are taken per day by each nurse working in the blood collection unit.

Table 2. Preanalytical error groups and their distribution in different laboratory working groups.

	Inpatients								Outpatients							
	Bio-chem-istry	Hor-mone assays	Hema-tology	Sedi-menta-tion rate	Co-agula-tion	Serol-ogy	Elisa	Total	Bio-chemis-try	Hor-mone assays	hema-tology	Sedi-menta-tion rate	coagu-lation	serol-ogy	Elisa	Total
Total number of samples	42152	4995	41504	9110	8220	5445	8492	119918	P< 0,05	83927	110718	38690	19683	30281	13801	415846
(100)Total number of errors (% of errors)	86 (5,83)	7 (0,47)	492 (33,33)	486 (32,93)	377 (25,54)	16 (1,08)	12 (0,81)	1476 (100)	7 (0,84)	13 (1,55)	112 (13,38)	484 (57,83)	211 (25,21)	6 (0,72)	4 (0,48)	837(100)
Lipemic	3	0	1	0	6	0	0	10	0	0	0	0	4	0	0	4*
Hemolyzed	18		4	4	23	5	6	60	2	1	0	3	8	0	1	15*
Delayed transport	18	1	5	4	1	1	1	31	2	0	0	29	0	0	0	31**
Tube breakage/ loss	0	0	0	6	2	0	0	8	0	0	0	12	10	0	0	22 n.s.
Empty tube	0	0	6	0	2	1	0	9	0	0	10	1	2	0	0	13 n.s.
Excess volume	0	0	0	48	17	0	0	65	0	0	0	11	10	0	0	21*
Clotted tube	4	0	401	326	231	0	0	962	0	0	34	349	80	0	0	463*
İnsufficent volume	15	4	29	78	73	3	4	208	1	3	20	76	88	1	3	192*
Wrong sample	17	1	7	2	5	2	0	34	0	0	1	1	3	2	0	7 *
Unsuitable tube	5	1	15	10	14	4	1	50	2	9	35	0	6	3	0	55*
Barcode error	6	0	24	8	3	0	0	41	0	0	12	2	0	0	0	14*
Error rate (% of type of sample) * p< 0,05 com-pared to inpa-tients.	0,2	0,14	1,19	5,33	4,59	0,29	0,14	1,23	0,0*1	0,02*	0,1*	1,25*	1,07*	0,02*	0,03*	0,2*

n.s.: not significant

Discussion

In this study, most pre-analytical errors occurred during sample collection in both inpatients and outpatients. Clotted samples representing more than half of the total errors of inpatient´s blood samples were higher in samples from inpatients compared to outpatients. This is probably caused by slow blood flow into tubes with anticoagulant, causing insufficient mixture of the anticoagulant. Tubes which include anticoagulant are smaller than those used for biochemistry tests (serum tube), and therefore the blood collection vacuum is lower during the blood draw with an evacuated tube. The needle position within the vein, on the other hand, can lead to interruptions of blood flow, when many tubes are drawn consecutively. Interruptions in blood flow may cause insufficient sample collection. Often, it is not possible to estimate the amount of blood that is taken into the tube in a horizontal position during the process before the end of the blood draw. Nurses who work in clinics with many duties may be distracted due to the intense work place; they may be in a hurry and therefore insufficiently mix up samples, contributing to clot formation. Using an injector instead of an evacuated tube for blood collection from inpatients leads to errors related to the blood content in the tube. The number of inpatients per nurse in clinics requiring blood drawing however, seems not too high in our study. In our experience some nurses refrain from using a vacuum blood drawing system. Sometimes, when the number of blood samples to be taken from the patient is low, an injector is preferred instead of a vacuum system. This can be eliminated only by eliminating any other possibilities after intense training with the vacuum system used. This seems urgent after it was observed, that some nurses, after drawing blood with an injector, wait to inject the blood into a vacuum tube by plunging the needle of the injector into the tube stopper. In the case of small diameter needles used for sample collection, hemolyzed, clotted or inadequate volume samples may occur. In some cases blood was transferred into an opened vacuum tube. This can result in loss of blood sample.

In practice, nurses distinguish the sample tubes by their closure colors but, in contrast to the laboratory staff, do not have enough knowledge about the functions of tube additives. Therefore, it is important to be informed about the correct level of blood will be taken to the tube and the proper mixing of the tube after the blood drawing. Taking precautions that make the acceptance of tubes by nurses easier can reduce improper tube errors. The pre-analytical phase has more manual functions compared to other laboratory phases, and therefore contains more errors than the other phases [18]. Because nurses play an important role in taking and handling blood samples [2], they must be the focus of studies to reduce blood collection errors in the future.

Atay et al. [14] reported that blood sampling errors generally occur when the blood samples are drawn by nurses whose experience and training are not sufficient for blood drawing in clinics compared to phlebotomists. Several studies have reported the importance of continuous education for healthcare personnel involved in sample collection outside the laboratory [16,17,19]. Lillo et al. [20] have focused attention on the importance of educational programs for nurses to decrease sample errors in their study. Makitalo and Liikanen [2] reported that nurse education provides a basic knowledge of blood sampling; to reduce the pre-analytical errors, this should be extended in the curriculum and in-service training should be provided, and the certification of blood sampling should be considered. Da Rin [21] have described a comprehensive plan to prevent pre-analytical errors consisting of five interrelated steps: developing clear written procedures, enhancing healthcare professional training, automating functions, monitoring quality indicators, improving communication among healthcare professionals and fostering interdepartmental cooperation. In addition to all of these suggestions applied blood sampling training can increase the phlebotomy experience of nurses. The pre-analytical phase seems too complex to be standardized completely, after many pre-analytical errors are related to manual activities during this phase [2,17]. However, increasing the experience of phlebotomists can be effective in reducing pre-analytical errors.

This study's findings suggest that increasing the experience of nurses working in the blood collection unit due to drawing 200 blood samples per day is an effective way to lower the rate of pre-analytical errors in outpatients compared to inpatients. Sample rejection rates were higher due to clotted and insufficient samples in sedimentation and coagulation tubes, indicating that laboratory experts responsible for these parts of the laboratory investigations should seek different solutions for blood drawing experiences. In this context, some nurses claim that they cannot prevent sediment tubes from stopping vacuum before reaching the correct level arguing that the reason for errors are the tubes, not them.

Ensuring the continuity of education of nurses about the reasons leading to sample collection errors, to increase their knowledge and experience with blood collection, can reduce sample collection errors and hence total pre-analytical errors. The

compliance training in the new employee (nurse) orientation period can be included as an applied education, for example by working in the blood collection unit for a certain period of time. Here their knowledge and blood drawing experiences can be increased. A similar applied education can be used for nurses working in inpatient services. These approaches could be reduced the errors of sample collection stage.

As a result, pre-analytical errors, which create a risk in terms of safety for patients and hospital staff, can be reduced significantly. Besides, all tests repeated because of pre-analytical errors increase the amount of medical waste and the risk of infection as well as the causing extra work for hospital staff and the cost burden for hospitals. Therefore, continuing education and activities to increase knowledge and experience is an unavoidable necessity in order to reduce pre-analytical errors as much as possible.

Declaration of conflicting interests

The author declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

References

1. Bölenius K, Brulin C, Graneheim UH. Personnel's experiences of phlebotomy practices after participating in an educational intervention programme. Nursing Res Pract 2014;2014:538704 Doi:10.1155/2014/538704.
2. Makitalo O, Liikanen E. Improving quality at the preanalytical phase of blood sampling: Literature Review. Int J Biomed Lab Sci 2013; 2: 7-16.
3. Daglıoglu G. Klinik laboratuvarlarda kalite yönetimi: Altı Sigma protokolünün uygulanması. 2009. Available from: library.cu.edu.tr/tezler/7283.pdf. Accessed on June 19,2014.
4. Chawla R, Goswami B, Tayal D, Mallika V. Identification of the types of preanalytical errors in the clinical chemistry laboratory: 1-Year study at G.B. Pant hospital. Lab Med 2010; 41:89-92.
5. Plebani M. Quality indicators to detect pre-analytical errors in laboratory testing. Clin Biochem Rev 2012; 33: 85-8.
6. Salinas M, López-Garrigós M, Flores E, Santo-Quiles A, Gutierrez M, Lugo J, et al. Ten years of preanalytical monitoring and control: Synthetic balanced score card indicator. Biochem Med 2015; 25: 49-56.
7. Cuhadar S. Preanalytical variables and factors that interfere with the biochemical parameters: a review. OA Biotechn 2013;2: 1-7.
8. Ernst DJ. Preanalytical errors that occur after specimen collection. 2007. Available from:http://duiform.weebly.com/uploads/1/2/0/1/12016444/blood_preanalytical_errors_after_collection.pdf. Accessed on March 13,2015.
9. Simundic AM, Cornes MP, Grankvist K, et al. Colour coding for blood collection tube closures-a call for harmonization. Clin Chem Lab Med 2015; 53: 371-6.
10. Guder WG, Naraynan S. (eds) Pre-Examination Procedures in Laboratory Diagnostics. Preanalytical aspects and their Impact on the quality of medical laboratory tests. Berlin, Boston; Walter de Gruyter GmbH;2015.
11. Lippi G, Chance JJ, Church S, et al. Preanalytical quality improvement: from dream to reality. Clin Chem Lab Med 2011; 49: 1113-26.
12. Sinici Lay I, Pınar A, Akbıyık F. Classification of reasons for rejection of biological specimens based on pre-preanalytical processes to identify quality indicators at a university hospital clinical laboratory in Turkey. Clin Biochem 2014; 47: 1002-5.
13. Abdollahi A, Saffar H, Saffar H. Types and frequency of errors during different phases of testing at a clinical medical laboratory of a teaching hospital in Tehran, Iran. North Am J Med Sci 2014; 6: 224-8.
14. Melkie M, Girma A, Tsalla T. The practice of venous blood collection among laboratory and non-laboratory professionals working in Ethiopian Government Hospitals: a comparative study. BMC Health Services Res 2014; 14: 88.
15. Atay A, Demir L, Cuhadar S, et al. Clinical biochemistry laboratory rejection rates due to various types of preanalytical errors. Biochem Med 2014; 24: 376–82.
16. Simundic AM. EFLM WG-PA European survey on pflebotomy practices. Available form:http://www.labquality.fi/@Bin/2827774/AnaMaria+Simundic_+Managing+the+Qualiy+of+Preanalytical+Phase_Labquality+days_2015.pdf. Accessed on April 01,2016.
17. Yüksel H, Kaplan İ, Toprak G, et al. A questionnaire study among nurses: awareness of blood and urine sample collection procedures. Clin Chem Lab Med 2014; 52: e159-e161.
18. Wallin O. Preanalytical errors in hospitals. Implications for quality improvement of blood sample collection. Thesis, Department of Medical Biosciences, Clinical Chemistry Department of Nursing Umeå University, Umeå, Sweden;2008.
19. Dorotić A, Antončić D, Biljak DR, Nedić D, Beletić A. Hemolysis from a nurses' standpoint – survey from four Croatian hospitals. Biochem Med 2015; 25: 393-400.
20. Lillo R, Salinas M, Lopez-Garrigos M, et al. Reducing preanalytical laboratory sample errors through educational and technological interventions. Clin Lab 2012; 58: 911-7.
21. Da Rin G. Pre-analytical workstations: A tool for reducing laboratory errors. Clin Chim Acta 2009; 404: 68-74.