Opinion Paper

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Standardization of blood tube closure colors may be important in reducing tube selection errors of non-laboratory personnel

Kan tüpü kapak renklerinin standartizasyonu laboratuvar dışı personelin tüp seçme hatalarını azaltmada önemli olabilir

Abstract: Errors in laboratory medicine contribute significantly to the overall risk of errors in healthcare. The majority of these laboratory errors occur in the pre-analytical phase. Control of pre-analytical variables is difficult because many steps are outside the control of the laboratory management. Pre-analytical errors may be reduced by active monitoring and control of all possible errors that are caused by non-laboratory personnel drawing blood, continuous training, use of quality indicators and implementation of standard procedures. Non-laboratory personnel make blood collection tube selection mostly according to the closure color, so standardization of color coding for blood tube closures could help reduce sample collection errors. It is important that European Federation of Clinical Chemistry and Laboratory Medicine calls all stakeholders in the healthcare sector to harmonize color coding for blood collection tube closures. Non-laboratory personnel drawing blood can be taught the additives in blood tubes and their functions to reduce errors during the sample collection stage. In addition, standardization of the closure colors of blood tubes should be supported, and non-laboratory personnel drawing blood should be informed when there is a change in the tube closure colors used by the hospital until this standardization is achieved.

Keywords: Patient safety; Pre-analytical error; Sample collection; Tube closure color; Non laboratory personnel drawing blood.

Özet: Laboratuvar tıbbındaki hatalar, sağlık bakımındaki genel hata riskine önemli oranda katkıda bulunur. Bu laboratuvar hatalarının çoğunluğu preanalitik safhada oluşur. Pek çok basamağı laboratuvar yönetimünün kontrolü dışında olduğundan preanalitik değişkenlerin kontrolü zordur. Preanalitik hatalar, kan alımı yapan laboratuvar dışı personelin sebep olduğu tüm olası hataların aktif olarak izlenmesi ve kontrolü, sürekli eğitim, kalite göstergelerinin kullanılması ve standart prosedürlerinin uygulanması ile azaltılabilir. Laboratuvar dışı personel, kan tüpü seçimini çoğunlukla kapak rengine göre yaptığından kan tüplerinin kapak renginin standartizasyonu örnek toplama hatalarını azaltmaya yardımcı olabilir. Avrupa Klinik Kimya ve Laboratuvar Tibbi Federasyonunun, kan toplama tüplerinin renk kodlamasının uygulanması için sağlıklar sektöründeki tüm paydaşlara yaptığını çağrı önemlidir. Örnek toplama aşamasındaki hatalar azaltmak için laboratuvar dışı kan alım personeeline kan tüplerinin içindeki katkı maddeleri ve onların fonksiyonları öğretilebilir. Ayrıca tüp kapak renklerindeki standartizasyon desteklenmeli ve bu standartizasyon sağlanana kadar hastanenin kullandığı tüp kapak renklerinde değişiklik olduğunda laboratuvar dışı kan alımı yapan personeller bilgilendirilmelidir.

Anahtar kelimeler: Hasta güvenliği; Preanalitik hata; Örnek toplama; Tüp kapak rengi; Kan alan laboratuvar dışı personel.

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Introduction

Quality in the laboratory mainly based on patient safety through the determination and prevention of errors [1]. Errors in laboratory medicine can make a significant contribution to the overall risk of error in healthcare. Laboratory errors are classified in three different phases: pre-analytical, analytical and post-analytical. The majority of these laboratory errors occur in the pre-analytical phase which accounts for nearly 60%–70% of all errors [2–4]. The pre-analytical phase is very complex and many of the steps are human dependent [5]. Pre-analytical errors can occur at any stage of the pre-analytical phase, such as patient preparation, sample collection, transportation, and preparation for analysis and storage [2, 6]. Possible reasons for high error rates in the pre-analytical phase are that many steps in the pre-analytical phase are outside of the laboratory and different levels of training are received by non-laboratory professions [2]. In sample collection which is one of the stages of the pre-analytical phase, the effect of the person drawing blood is significant and the pre-analytical error rate is two to four times higher for non-laboratory phlebotomists than laboratory staff [4]. Incorrect test requests, wrong/missing identification, wrong container or tube, insufficient or excess sample volume and insufficient mixing of the sample are errors of sample collection [3, 7].

The lack of standardization of the closure colors of the blood collection tubes may cause to wrong choice of tube for blood sample collection by non-laboratory personnel and an increase in sample collection errors.

In the past, efforts have been made to standardize to the tube closure colors, but standardization has not been achieved for a variety of reasons. Recommendations for tube closure color coding were first made in the ISO 6710: 1995 standard. In some of the later published laboratory standards, recommendations for tube closure color were addressed. However, there is still heterogeneity in the available colors of the tube closures in the market. Simundic et al. in their opinion paper published on behalf of European Federation of Clinical Chemistry and Laboratory Medicine (EFLM), reported that the non-standardization of tube closure colors is an important source of pre-analytical errors. They have called on all stakeholders in the healthcare sector to harmonize color coding for blood collection tube closures. The working group for the standardization of the colors of the blood collection tube closures (TFG-STCC) by EFLM was established with the aim to initiate and manage a dialog between interested parties in order to achieve global harmonization of the color coding for blood collection tube closures (caps) and labels. Table 1 shows the closure colors of blood collection tubes recommended in published laboratory standards and the color coding for collection tube closures recommended by EFLM [2, 8].

Blood tubes produced by different manufacturers in different closure colors may also cause confusion if samples from different hospitals sent to large reference laboratories are in tubes with different closure colors [2]. When the tube supplier company for a hospital laboratory changes, the tube closure colors used for some laboratory tests may change. In this case, varying tube closure colors can cause errors related to tube selection. The probability of error may be further increased in facilities where sample labels containing specific information about the color of the tube stopper are used [2]. Wrong container ratios may increase at centers where blood samples are taken from non-laboratory personnel who make blood tube selection according to the closure color.

Nurses are primarily responsible for collecting blood samples in Turkey [9]. In our hospital, blood from inpatients is drawn by nurses. Nurses who are non-laboratory professions make the choice of blood tube according to the closure color. For example: they define a tube to be used for a hormone test as “a red closure tube”. Blood collection tubes and additives are identified not only in writing on the tubes but also by the color of the tube closures [2]. Nurses generally do not know the additives and their functions in the blood tubes because the choice of blood tube used for the blood sample and the additives in the blood tubes are not part of the nursing education and they rarely experience blood sampling during their internship.

The aim of this paper is to draw attention to standardization of blood collection tube closure colors being even more important in centers where blood tube choice and blood sampling is carried out by non-laboratory personnel, by evaluating the blood tube selection behaviors of our non-laboratory personnel (nurses) who take blood in the inpatient services of our hospital.

In the survey that we applied to the nurses working in the inpatient services of our hospital to evaluate their blood tube selection behaviors, nearly 80% of nurses have stated that they identified the correct tube in the drawing of blood according to tube closure color rather than the additives in the blood collection tube. If the color of the blood tube closure has changed, it takes 79% of nurses <4 weeks to learn the color of the new closure.

There was no statistically significant difference between frequencies of socio-demographic characteristics and each of the survey questions (Table 2). Survey questions and answers to the questions about choosing the correct blood tube of nurses were given Table 3. Our
laboratory test guide contains information on the possible closure colors of the tube from which the sample can be taken for a laboratory test.

### Discussion

Nurses working in shift mode, especially in inpatient services, can make more errors when choosing a tube for sampling, until they adapt to the new closure colors.

There are not many studies reported in the literature on the error rate associated with different tube closure colors. In relation to this topic, it was reported that a change of tube manufacturer may lead to four-fold increase in samples drawn into the wrong container in the first 3 weeks after a change is implemented [2]. The wrong choice of tube, which is often noticed before transfer to the laboratory, can be observed either before or following the intake of the blood sample; nurses ask their colleagues to confirm that they have taken the blood sample in the correct blood tube or take blood sample again in the correct blood tube. In practice, nurses distinguish sample tubes by their closure colors but, in contrast to the laboratory staff, do not have enough knowledge about the functions of tube additives. They recognize the blood

| Specimen type | Additive | ISO 4822 (1981)* | BS 4851 (1982) | ISO 6710 (1995) | CLSI H1-A5 (2003) | CLSI GP41-A6 (2007) | Swedish standard SS-872805 (2011) | EFLM proposal (color) |
|---------------|----------|------------------|----------------|------------------|------------------|---------------------|------------------------|----------------------|
| Serum         | Clot activator | Z (no additive) | White (no additive) | Red | Red | Red | Red |
| Serum with gel| Gel, clot activator | NA | NA | NA | NA | Red | Yellow |
| Plasma        | Li-Heparin | LH (Li-heparin) | Orange (Li-Heparin) | Green | Green | Green | Dark green |
| Plasma with gel| Gel, Li-heparin | NA | NA | NA | NA | Green | Light green |
| Plasma        | Citrate (1:9) | 9 NC | Indigo | Light blue | Blue | Blue | Light blue |
| Whole blood   | Citrate (1:4) | 4 NC | Mauve | Black | Black | NA | Black |
| Whole blood   | EDTA | KE (K salt) LE (Lithium salt) NE (Sodium salt) | Pink | Lavender | Lavender | Lavender or Pearl | Lavender |
| Plasma EDTA with gel | Gel, EDTA | NA | NA | NA | NA | Lavender or Pearl | White or pearl |
| Plasma        | Glycolytic inhibitor | FX | Yellow | Grey | Grey | Grey | Grey |

*ISO 4822 standard had suggested a letter coding for different anticoagulants (the standard did not contain color coding proposal). *(Former H03-A6). Adapted with permission from https://www.eflm.eu/files/efcc/selection9IFCCeNewsJune2016%20.pdf [8].
tube through the tube closure color. The number of nurses who know the tube additives such as gel, clot activator, heparin, etc. is lower compared to laboratory technicians. The wrong blood tube as defined by nurses could be suitable for analyzing blood due to the same additive; however, nurses think that they have made an error as they recognize the blood tube through the tube closure color. In this case, nurses take the blood sample again. For this reason, it is important to inform nurses drawing blood when there is a change in the closure colors of the tubes used by the hospital.

Even if wrong container or tube errors account for a small percentage such as 15% of the total pre-analytical errors, they do increase the amount of re-collection and re-work [3, 7, 10]. Lippi et al. reported that standardization of the tube closure colors is an important factor in reducing blood collection errors and can help users to easily identify the correct tube type [3]. In order to reduce the number of errors in the pre-analytical phase, which is carried out outside the clinical laboratory and the most complex process of the total testing process, it is important to actively monitor and control all possible defects that are caused by non-laboratory personnel drawing blood, deliver continuous education and training, develop communication and teamwork among health professionals, use quality indicators and implement standard procedures [11].

The results of the survey we applied to nurses in the inpatient services indicate that the nurses mostly choose the blood tube according to the closure color of the tube. After the results of the survey were assessed, a table

Table 2: Socio-demographic characteristics.

| Age (years) | n (103) (%) |
|-------------|-------------|
| 20–30       | 29 (% 28.2) |
| 31–35       | 17 (% 16.5) |
| 36–40       | 39 (% 37.9) |
| 41–50       | 18 (% 17.5) |

Educational level

| Level       | n (%) |
|-------------|-------|
| High school | 3 (2.9) |
| Associate's | 38 (36.9) |
| Undergraduate | 56 (54.4) |
| Graduate    | 6 (5.8) |

Duration of work in the hospital

| Duration | n (%) |
|----------|-------|
| 2–5      | 57 (55.3) |
| 6–10     | 24 (23.3) |
| 11–15    | 13 (12.6) |
| 16–20    | 5 (4.9) |
| ≥21      | 4 (3.9) |

Duration of profession

| Duration | n (%) |
|----------|-------|
| 2–5      | 19 (18.4) |
| 6–10     | 19 (18.4) |
| 11–15    | 20 (19.4) |
| 16–20    | 24 (23.3) |
| ≥21      | 21 (20.4) |

The number of work shifts (from 16:00 to 08:00)

| Shifts          | n (%) |
|-----------------|-------|
| None            | 26 (25.2) |
| 3               | 10 (9.7) |
| ≥4              | 67 (65.0) |

Table 3: Survey questions and answers to the questions about choosing the correct blood tube of nurses.

| Survey questions                                                                 | Strongly agree frequency (%) | Agree frequency (%) | Neutral frequency (%) | Disagree frequency (%) | Strongly disagree frequency (%) |
|---------------------------------------------------------------------------------|-------------------------------|--------------------|-----------------------|------------------------|-------------------------------|
| 1 I know which collection tube to use in the blood drawing                      | 64 (62.1)                    | 36 (35)            | 0                     | 2 (1.9)                | 1 (1.0)                       |
| 2 I ask to my colleagues which collection tube to use in the blood drawing      | 8 (7.8)                      | 26 (25.2)          | 8 (7.8)               | 37 (35.9)              | 24 (23.3)                     |
| 3 I ask to laboratory staff which collection tube to use in the blood drawing   | 7 (6.8)                      | 22 (21.4)          | 13 (12.6)             | 35 (34.0)              | 26 (25.2)                     |
| 4 I ask to laboratory staff which collection tube to use in the blood drawing for only external laboratory testing | 27 (26.2)                    | 55 (53.4)          | 6 (5.8)               | 12 (11.7)              | 3 (2.9)                       |
| 5 I identify the correct tube in the blood drawing according to tube closure color rather than the additives in the blood collection tube | 27 (26.2)                    | 54 (52.4)          | 7 (6.8)               | 10 (9.7)               | 5 (4.9)                       |
| 6 It takes longer than 4 week to learn to new closure color of color code changing tubes | 4 (3.9)                      | 10 (9.7)           | 8 (7.8)               | 59 (57.3)              | 22 (21.4)                     |
| 7 The change of color coding of the blood collection tubes increases my chance of an error | 17 (16.5)                    | 51 (49.5)          | 9 (8.7)               | 18 (17.5)              | 8 (7.8)                       |
showing the closure color of the blood tubes was prepared and provided to hang in all units taking blood.

When tubes from one manufacturer are replaced by the tubes from another manufacturer that uses different color coding, there may be an increase in wrong tube errors associated with the collection stage. Therefore, I support the road map proposed by Simundic et al. on standardization of tube closure colors:
- All stakeholders, including all manufacturers working in the field, should be invited to join a dialog to establish a universally acceptable color coding standard for blood collection tube closures;
- Standard writing bodies (ISO, CLSI) should add the color coding standard agreed on to the existing recommendations;
- Manufacturers should implement the agreed color coding standard [2].

However, training about the additives of blood tubes and their functions for nurses drawing blood may be helpful in reducing sample collection errors.

In conclusion, the studies done to reduce errors of wrong container or tube as well as related studies the standardization of tube closure color may be useful in reducing sample collection and hence pre-analytical errors. Reducing laboratory errors will have a positive effect on the need for test repetition and repeated blood sampling which causes the patient discomfort and risk of delayed diagnosis or therapy, and will be substantially improve patient safety. Also, there will be positive effects on preventing an increase healthcare costs.

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