Experience in Reducing Hemolysis in the Emergency Laboratory

Acil Laboratuvarda Hemoliz Oranlarını Azaltma Deneyimi

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ÖZET

Amaç: Hemolizli örnekler genellikle klinikler ve laboratuvar arasındaki ekonomik ve klinik sorunların önemli bir nedenidir. Acil Serviste alınan numunelerde hemoliz oranı, diğer hastane birimlerine kıyasla belirgin şekilde daha yüksektir. Çalışmamızda acil servis numunelerinde hemoliz oranlarını düşürmeyi hedefledik.

Metod: Haçkalı Baba Devlet Hastanesi Acil laboratuvarına Temmuz 2018-Mart 2019 tarihlerinde gelen toplam 31.277 biyokimya kan örneklerinin hemolitik indeks analizleri 2 ayrı döneme ayrılarak değerlendirilmiştir. Genellikle enjektörle kan alınan 6 aylık birinci dönemde biyokimya otoanalizörüne hemoliz indeksleri (HI) tanımlanmış ve her test için aplikasyon prospektüsünde belirtilen hemoliz indeksi girilmiştir. Hemolizden etkilenmiş test sonuç raporunda belirtilmiştir. Son 2 aylık ikinci dönemde ise hizmet içi eğitim verilerek enjektör yerine Luer Lok vakumlu kan alma iğne ucu ve holderi kullanımı sağlanmıştır. Her iki dönemin verileri retrospektif olarak Laboratuvar Bilgi Yönetim Sistemi (LBYS)'den elde edilmiştir. Hemoliz indeksinde kestirim değeri ≥0.5 g/L olarak alınmıştır. Hemoliz oranları arasındaki istatistiksel fark ki-kare testi ile hesaplanmış ve istatistiksel anlamlılık $p<0.05$ olarak kabul edilmiştir.

Bulgular: Birinci dönemde Acil servisten toplam 24.213 biyokimya numunesi gelmiş bunların 8.725'inde (%36) hemoliz saptanmıştır. İkinci dönemde ise gelen 7064 numunenin 949'unda (% 13.4) hemoliz saptanmıştır. Hemolizden etkilenmiş testlerin oranı ise birinci dönemde %9.1 (32.980/ 292.347) iken ikinci dönemde %3.4'tür (2.984/86.808). Fark istatistiksel olarak anlamlıdır. Hemolizli numune oranlarında yaklaşık %63'lük, hemolizden etkilenmiş test sayısında ise %70'lik azalma olmuştur.

Sonuç: Dünyada acil servislere başvuran hasta sayısındaki artış göz önüne alındığında, laboratuvar hatalarının ve gecikmelerinin en aza indirilmesi gerekmektedir. Hemoliz oranlarını azaltmak için hizmet içi eğitimleri tekrarlamak ve Luer-Lok vakumlu kan alma iğne ucu ve holderi kullanımını arttırmak doğru bir adım olarak görülmektedir.

Anahtar Sözcükler: Hemoliz, Interferans, Preanalitik

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ABSTRACT

Aim: Hemolyzed specimens are often a significant cause of economic and clinical problems between the clinics and the laboratory. The rate of hemolysis is markedly higher in the Emergency Department (ED) as compared with other hospital departments. We aimed to reduce the rate of hemolysis in the ED.

Methods: Hemolytic index (HI) specific for each biochemistry test was defined on the autoanalyzer. In the first 6-month phase, the blood samples were usually drawn by injector. In the second 2-month phase, they were drawn by Luer Lok adapter with holder. Data were obtained retrospectively from the Laboratory Information System. The cut-off value was taken as ≥0.5 g/L. The statistical difference between hemolysis ratios was calculated by chi-square test and statistical significance was accepted as $p < 0.05$.

Results: In first phase, hemolysis was detected in 8.725 (36%) of 24.213 total samples. In second phase, hemolysis was detected in 949 (13.4%) of 7064 total samples. The rate of hemolysis affected tests were 9.1% (32.980/292.347) in first phase and 3.4% (2.984/86.808) in second phase. The differences are statistically significant ($p < 0.05$). The rate of hemolysis samples and hemolysis-affected tests decreased by 63% and 70% respectively.

Conclusion: Considering the increase in the number of patients admitted to EDs in the world, laboratory errors and turnaround time should be minimized. In order to reduce hemolysis rates, it is considered as a correct step to repeat the trainings and to increase the use of Luer-Lok.

Key words: Hemolysis, Interference, Pre-analytical

INTRODUCTION

Emergency departments (EDs) are characterized by high workload and stressful care environments. The working conditions enhance the frequency of fault so pre-analytical errors are markedly elevated compared with other hospital departments (1). Most of the errors associated with the total testing process occur in the pre-analytical phase (70-80%). Preanalytical errors may be leading cause of inappropriate treatment or misdiagnosis (2,3).

Hemolysis, bilirubin, and lipids (HIL) are the most common and important sources of pre-analytical error in laboratory medicine (4). Because of their spectral characteristics, these substances can cause optical interference. To overcome disadvantages of HIL interferans, automated HIL-indices analysis was applied in clinical laboratories (5). In 2012, the Clinical and Laboratory Standards Institute (CLSI) published guidelines for HIL-indices to increase the accuracy of patient test reports (6).

Hemolysis is defined as the pathological process of breakdown of red blood cells and release of hemoglobin and other cellular components into the plasma, which is typically accompanied by varying degrees of red tinge in serum or plasma once the blood specimen has been centrifuged. This interference will be more important depending on the magnitude assayed and the degree of hemolysis (7).

Variety of factors including collection, handling, transportation, processing and storage of blood specimens are contributing to hemolysis (8). A sample with hemolysis is inappropriate for many analysis; e.g. creatinine kinase (CK), lactate dehydrogenase (LDH), alanine aminotransferase (ALT), aspartate aminotransferase, (AST), potassium (9). The presence of this interference in the samples affects the analytical determination of the biochemical tests, having as a consequence the need to recollect samples, delays in patient diagnosis and follow-up, decreased patient safety, increased costs, … etc (8,10). This causes disruption in healthcare, especially in EDs. Considering the increase in numbers of patients calling at EDs globally, laboratory based delays and lapses need to be minimized (11).

The main reason of excess rate of hemolysis in EDs is to draw blood from newly inserted IV catheters to direct vacuum tubes or indirectly by using injector (12,13). Several methods have been investigated in order to

minimize hemolysis, especially in the pre-analytic phase. One of such methods involves the Luer-Lok adapter with holder, which has a lock mechanism and typically limits transmission. Luer-Lok adapter with holder allows blood collection from an IV catheter, facilitating direct draw of specimen from the catheter to the evacuated tube. The one-piece transfer device of the Luer-Lok provides a secure connection that enables sufficient blood flow and the best quality sample. It also minimizes the potential for blood exposure and needle stick injuries during transfer of the specimen from the syringe to evacuated tubes (11).

In the present study, we aimed to reduce the rates of hemolysis in the ED by providing training the emergency personnel drawing blood and using Luer-Lok collected from IV catheters.

MATERIALS AND METHODS

The study was performed at the Biochemistry Laboratory of the Akçaabat Haçkalı Baba State Hospital, Trabzon, Turkey. Akçaabat Haçkalı Baba State Hospital is a seconder care 230-bed hospital, serving approximately 140.000 patients ED annually. 50.000 ED biochemistry samples are analyzed annually in the biochemistry laboratory. ED biochemistry samples are analyzed on the Beckman Coulter AU680 clinical chemistry analyzer (Beckman Coulter, Brea, CA, USA).

The Beckman Coulter AU680 is a novel fully automated analytical platform designed for the analysis of routine chemistry assays. The AU680 analyzer is also able to detect HIL interferans in blood samples. Patient samples are diluted with the LIH reagent and the absorbance is measured at 6 wavelengths: 410/480 nm and 600/800 nm for hemolysis, 480/570 nm and 600/800 nm for icterus, and 660/800 nm for lipemia. This spectrophotometric method estimates the levels of hemoglobin, bilirubin, lipid and offers as semi-quantitative index values according to mathematical algorithms. In addition, the index values influenced of test can be assigned for each test on the analyzer's test application pages. If interfering concentration is present in a sample, semi-quantitative index values are reported along with the results of the sample.

As a first step, HIL index measurement started on the Beckman Coulter AU680 analyzer. The knowledge of the hemolysis degree of a sample is very important. Test-specific HIL indices were performed to the analyzer for twenty-three tests: Total Protein, Albumin, Creatinine, Urea, Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), γ-Glutamyl transferase (GGT), Lactate Dehydrogenase (LDH), Calcium, C-Reactive Protein (CRP), Total Bilirubin, Glucose, Amylase, Direct Bilirubin, Creatine Kinase (CK), CK-MB, Alkaline Phosphatase (ALP), Ethanol, Magnesium, Valproic acid, Carbamazepine, Lithium, Phenytoin. The analyzer warns when there is a test affected by interference, thanks to the test-specific HIL index. The flag on the analyzer is automatically added to the result reports in the Laboratory Information System (LIS) as the test interpretation 'may have been affected by hemolysis / lipemia / icter'.

The first 6-month phase, which was the first phase, was evaluated to see the frequency of hemolysis. Observations in the emergency department revealed that blood was taken with an injector. Training was organized for the improvement of preanalytic practices. The hemolysis rate was shared with ED. Nursing staff became more aware of their role in reducing hemolysis when data was shared. Luer-Lok holder was introduced, which allows blood to be drawn directly from the IV catheter into vacuum tubes in order to reduce the use of injectors. Using of Luer-Lok disseminated throughout the ED. The effectiveness of the new application was assessed in the next 2 months. For this purpose, hemolysis was evaluated in 31,277 biochemistry blood samples between July 2018 and March 2019.

This study was performed with the approval of Trabzon Provincial Health Directorate. The data were obtained retrospectively from LIS. Cut-off value was taken as 0.5 g/L in the

hemolysis index. Statistical difference between hemolysis rates was calculated by chi-square test and statistical significance was accepted as $p < 0.05$.

RESULTS

31.277 biochemistry samples came from the Emergency Department during the study process. Hemolysis was detected in 8.725 (36%) of 24.213 blood samples in the first phase. In the second phase, hemolysis was detected in 949 (13.4%) of the 7064 blood samples (Table 1). There was a 63% reduction in hemolysis sample rates. The difference between both phase was found statistically significant.

Since test-specific hemolysis index values are entered, the rates of hemolysis-affected tests were also compared in both phase. While the rate of tests affected by hemolysis is 9.1% (32.980 / 364.267) in the first phase, it is 3.4% in the second phase (2.984 / 86.808) (Table 1). There was a 70% reduction in the number of tests affected by hemolysis. These observed present changes among the phases were found to be statistically significant.

According to percent change of the rates of hemolysis among phases, luer-lock adapter using showed a predominant effect on the reducing of the rate of hemolysis index.

DISCUSSION

A hemolysis sample can disrupt the results of many laboratory tests and cause erroneous laboratory results (12). The American Society of Clinical Pathology established a benchmark of 2% or lower for hemolysis rates among laboratory blood samples and most units outside the EDs achieve this level or better (14). A number of studies have shown that the hemolysis rates in blood samples at the EDs are considerably higher compared to other healthcare units. An analysis performed by the Working Group on Laboratory Errors and Patient Safety (WG-LEPS) of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) and the Global Pre-analytical Scientific Committee (GPSC) involving 391 clinical laboratories worldwide has reported that, the rate of hemolysis is between 1-5% in the vast majority (over 60%) of clinical laboratories. The departments with the highest hemolysis rates were the emergency department (up to 53%), the pediatric department (16%), and the intensive care unit (7%) (15). In the articles of Howanitz et al. the hemolysis rates among the 722 laboratories studied ranged from less than 1% up to 36% (16). Hospital EDs have been identified as a source of hemolyzed samples, with observed hemolysis rates ranging from 6.8% to 19.8%, and some increase up to 30%. These levels are markedly elevated compared with other hospital units (17). According to present study results, 36% and 13.4% hemolysis sample rates are consistent with previous publications. Adoption of Luer Lok reduced hemolysis of ED by %63. However they didn't still met the overall ED goal of %2 hemolysis.

A Q-Probes survey by the College of American Pathologists showed that 71% of laboratories reported little to no progress in addressing the problem of hemolyzed specimens (18). However, hemolysis may produce unreliable laboratory values requiring unnecessary repeated testing that results in excess patient discomfort, higher costs, increased nursing time, and delays to definitive acute care. Laboratory medicine has identified ED hemolysis as a significant quality issue owing to its impact on efficiency (14).

Table 1. Comparison of hemolytic samples and hemolysis affected tests in two phase.

	Phase 1	Phase 2
Number of samples (n)	24.213	7.064
Number of tests (n)	364.267	86.808
Hemolytic samples (n, %)	8.725, %36	949, %13.4
Hemolysis affected tests (n,%)	32.980, %9.1	2.984, %3.4

The presence of hemolysis in blood samples usually necessitate subsequent sampling, which in turn can lead to delayed diagnosis and treatment of patients, loss of workforce, elevated costs, and communication problems between the emergency department and the laboratory (8).

Due to the importance of knowing the degree of interference of the different levels of hemolysis over biochemical determinations, test-specific HIL indices are crucial for the proper hemolysis management. During the study period, thanks to the use of serum-specific serum indices, we reported to 35,964 of 451,075 tests (8%) with the interpretation of 'may be affected by hemolysis'. If we did not use it, we had to request a new sample for 9674 hemolysis samples (30%). The Laboratory also added value to the postanalytic process by warning about interference. In studies on unnecessary test request rates, results vary greatly in the range of 4.5-95% (19). In places where unnecessary test request rates are high, adding specific comments to the test can reduce unnecessary repetitive sampling.

Preanalytic processes (both technique and equipment) play an important role in hemolysis rates (14). One of the main issues in the laboratory should be to seek solutions to the prevention of hemolysis in blood samples taken from the IV catheter in the ED (20). Halmand et al. showed that hemolysis occurred in 3.3- 77% of the blood samples taken from the IV catheter (21). Orem et al. (22) investigated the effect of the rapid coagulated serum tube (BD Vacutainer) and Luer-Lok (BD Vacutainer) on hemolysis. They showed that when using Luer-Lok, hemolysis decreased by up to 50%. In another study conducted in the ED, Postigo et al. (22) found that using the catheter adapter with a partially pressurized tube reduced the rate of hemolysis from 27.8% to 0.6%. In addition, in a study involving 50 cases in the emergency department, Kaplan et al. Compared the use of syringes and Luer-Lok in the sampling method and concluded that Luer-Lok caused a decrease in hemolysis (22) Lippi et al. (23) tested a similar tube holder apparatus (Greiner Holdex®) in the ED and recorded a decrease in hemolysis rates. It claims that the adoption of tube-holding systems will reduce errors during blood draw and thus increase patient care and reduce costs. Aykal et al. (24) emphasized that periodic staff training is important for improving the preanalytic phase and decreasing hemolysis rates.

Limitations in present study, the use of Luer-Lok has been restricted in patients in the resuscitation area of the ED, where the use of injectors continued partially. However, blood biochemistry from the entire emergency room was included in the evaluation.

Our goals we can continue: track the % hemolysis regularly and share this information with EDs; integrate laboratory and nursing competencies to standardize consistent use of policies on blood collection process; continual educational process updates require multiple training sessions and ongoing feedback; continual resource for introduction to best practices and state of art products.

The laboratory has made qualitative and quantitative progress following training and the use of Luer-Lok. In two months, a 63% reduction in hemolysis samples and a 70% reduction in tests affected by hemolysis was achieved. Periodically repeating training and using Luer-Lok adapter, which allows blood to be taken from the IV catheter, is seen as the right step to reduce hemolysis rates. Standardization was generally achieved in blood collection from the IV catheter. Better sample quality improved accuracy of test results and general patient care. Thus, diagnosis and treatment delays were decreased. Better sample quality led to more affordable costs. The safety of health workers was improved by minimizing exposure to blood and needle tip injury. Improved communication between the emergency department and the laboratory and improved staff morale.

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