Avrupa Bilim ve Teknoloji Dergisi
Sayı 23, S. 243-247, Nisan 2021

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
No. 23, pp. 243-247, April 2021

Research Article

Use of Plasma Tube for the Emergency Tests in Clinical Chemistry Laboratory

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(First received 19 January 2021 and in final form 28 March 2021)

(**DOI:** 10.31590/ejosat.864325)

ATIF/REFERENCE: Şahingöz Erdal, G., Işıksaçan, N., Kasapoğlu, P., Gedikbaşı, A. & Koşer, M. (2021). Use of Plasma Tube for the Emergency Tests in Clinical Chemistry Laboratory. *Avrupa Bilim ve Teknoloji Dergisi*, (23), 243-247.

Abstract

The major considerations for the STAT testing performed in laboratories are to obtain a fast and accurate test result. Increasing number of instruments and methods have been developed for making it possible to perform the STAT testing on plasma rather than serum. The aim of this study is to compare the STAT test results of the serum and plasma sample tubes. Venous blood samples of 78 patients were collected into BD Vacutainer®SST™II Advance serum gel and Vacutainer®Barricor™ plasma tube. The sampling orders of the tubes were switched during blood collection and loading the tubes into the instruments in order to ensure randomization. It was ensured the tubes were inverted, completely filled, and were allowed serum tubes to clot for a minimum of 30 minutes from the time of blood collection. It was determined that the chloride and sodium tests had a good concordance and the remaining tests had a strong level of concordance. Albumin, ALT, Amylase, AST, Bilirubin, Direct Bilirubin, BUN, Calcium, Chloride, Creatinine, Mg, Na, CK, CRP, Urea, BNP, troponin-T, D-dimer analysis was similar for both, with no significant difference.
While it helps to improve TAT since no clotting time is required to obtain plasma it also supports sample quality and accurate test results with the absence of fibrin formation at plasma tube which is possible at serum tube samples. Plasma tubes may be used instead of serum tubes due to the possibility of hemolysis caused by sample transfer required to obtain serum.

Keywords: Serum, Plasma tube, STAT testing, Clotting

Klinik Kimya Laboratuvarında Acil Durum Testlerinde Plazma Tüpü Kullanımı

Öz

Laboratuvarlarda gerçekleştirilen hızlı testler için ana hususlar hızlı ve doğru bir test sonucu elde etmektir. Hızlı testlerin serum yerine plazma kullanılarak gerçekleştirilmesini mümkün kılmak için artan sayıda cihaz ve yöntem geliştirilmiştir. Bu çalışmanın amacı, serum ve plazma örnek tüplerinin hızlı test sonuçlarını karşılaştırmaktır. 78 hastanın venöz kan örnekleri BD Vacutainer®SST ™ II Advance serum jeli ve Vacutainer®Barricor ™ plazma tüpüne toplandı. Randomizasyonun sağlanması için kan alma ve tüplerin aletlere yüklenmesi sırasında tüplerin örnekleme sıraları değiştirildi. Kan alma anından itibaren tüplerin ters çevrilmesi, tamamen doldurulması ve serum tüplerinin en az 30 dakika süreyle pıhtılaşması sağlandı. Klorür ve sodyum testlerinin iyi bir uyuma sahip olduğu ve kalan testlerin güçlü bir uyum düzeyine sahip olduğu belirlendi. Albümin, ALT, Amilaz, AST, Bilirubin, Direkt Bilirubin, BUN, Kalsiyum, Klorür, Kreatinin, Mg, Na, CK, CRP, Üre, BNP, troponin-T, D-dimer analizi her biri için benzerdi ve anlamlı bir fark yoktu .
Plazma elde etmek için pıhtılaşma süresinın gerekmemesi hızlı testin isüresinin kısalmasına yardımcı olurken, plazma tüpünde serum tüp örneklerinde görülebilen fibrin oluşumunun olmaması ise örnek kalitesini ve test sonuçlarının doğruluğunu destekler. Serum elde etmek için gerekli numune transferinin neden olduğu hemoliz olasılığı nedeniyle serum tüpleri yerine plazma tüpleri kullanılabilir.

Anahtar Kelimeler: Serum, Plazma tüpü, Hızlı test, Pıhtılaşma

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1. Introduction

Considering the urgency of the disease and the necessity of rapid patient circulation, shortening the duration of patient stay (LOS) in the emergency department is of critical importance for patients, doctors and other healthcare professionals. LOS is one of the most important quality indicators for mortality and morbidity risk [1,2]. Most patients presenting to the emergency department undergo laboratory tests and have a wide range of roles ranging from diagnosing the disease to managing treatment and managing critical diseases [3,4]. Since laboratory test return around time is an important determinant of LOS, late results of laboratory tests may delay critical decisions regarding patient care, increase the length of stay, and reduce efficiency in the emergency department [4-6].

Important points for STAT tests in biochemistry laboratories are to obtain fast and accurate test results. Therefore, an increasing number of tools and methods have been developed around the world to enable STAT tests to be performed on plasma tubes rather than on serum tube samples.

The aim of our study was to analyze the serum tube and plasma tube samples of the patients on the same device (Roche analyzer) and compare the results and evaluate the usability of the plasma tube samples in the routine.

2. Materials and Methods

2.1. Patients and equipment

Venous blood samples of 78 patients from the anesthesia and reanimation, emergency service and coronary intensive care unit departments of Bakırkoy Dr. Sadi Konuk Training and Research Hospital were collected into BD Vacutainer® SST™ II Advance serum gel tube (Becton Dickinson - USA) and BD Vacutainer® Barricor™ (Becton Dickinson- USA) plasma tube.

The sampling orders of the tubes were switched during blood collection and loading the tubes into the instruments in order to ensure randomization. It was ensured the tubes were inverted, completely filled, and were allowed serum tubes to clot for a minimum of 30 minutes from the time of blood collection.

2.2. Biochemical analysis

Patient blood samples were analyzed for Albumin, alanine aminotransferase (ALT), amylase, aspartate aminotransferase (AST), direct bilirubin, total bilirubin, blood nitrogen urea (BUN), calcium, chloride, creatinine, glucose, potassium, magnesium (Mg), sodium (Na), phosphorus, total protein, CK, C-Reactive Protein (CRP), B-natriuretic peptide (BNP), troponin T, D-Dimer. After the centrifugation hemolysed samples were not included in the study and the serum tube samples that contain fibrin observed were analyzed after aliquoting.

2.3. Ethical approval

The Ethics Committee of the Institute approved the study protocol (2020/87). The study protocol was explained and written consent was obtained from all patients before sampling.

2.4. Statistical analyses

The Number Cruncher Statistical System 2007 (Utah, USA) software was used for the statistical analysis. ICC test was used in the evaluation of concordance between the plasma and serum tubes whereas Cohen Kappa concordance levels were used in the evaluation of concordance between the decisions (<0.40: Weak; 0.40 – 0.59: Medium; 0.60 – 0.74: Good; 0.75 – 1.00: Strong). Wilcoxon Signed-Rank test was used for evaluating the biases between variants from two separate tubes. The results were within 95% of confidence interval and the statistical significance was $p<0.05$.

Table 1. Correlations of biochemical parameters in plasma and serum tubes

	Plasma tube		Serum tube				
	Mean±SD	Min-Max (median)	Mean±SD	Min-Max (median)	[a]p	Difference	ICC
Albumin	3.85±0.98	1.2-5.4 (4.1)	3.86±1.01	1.4-5.4 (4.1)	*0.344*	-0.01±0.24	***0.972****
ALT	36.1±52.31	5-329 (17.5)	36.37±52.99	5-339 (17.5)	*0.105*	-0.27±2.5	***0.999****
Amylase	79.54±59.6	13-355 (64.5)	79.14±58.69	12-349 (64)	*0.841*	0.4±5.57	***0.996****
AST	44.21±100.6	7-804 (21)	43.47±95.79	7-757 (20)	*0.239*	0.74±5.94	***0.999****
Bilirubin, Direct	0.45±0.94	0.1-5.8 (0.2)	0.45±0.93	0.1-5.8 (0.21)	*0.395*	0±0.03	***0.999****
Bilirubin, Total	0.79±1.18	0.1-7.5 (0.45)	0.8±1.18	0.1-7.5 (0.47)	*0.247*	0±0.04	***0.999****
BUN	23.66±16.07	6-67 (18.5)	23.88±15.97	6-68 (18)	*0.648*	0.12±1.17	***0.997****
Calcium	8.79±0.73	6.7-10 (8.99)	8.75±0.84	5.9-10.1 (8.92)	*0.513*	0.03±0.28	***0.945****
Chloride	99.63±6.27	84.9-129 (99.25)	99.22±5.36	85.9-113.6 (99.4)	*0.604*	0.4±5.06	***0.631****
Creatinine	1.01±0.78	0.3-4.3 (0.76)	1.01±0.79	0.3-4.4 (0.75)	*0.392*	0±0.05	***0.998****
Glucose	**120.76±30.97**	**80-241 (115)**	**118.17±30.04**	**76-228 (111.5)**	***0.001****	**2.59±6.54**	***0.977****
Potassium	**3.94±0.6**	**2.8-6.6 (4)**	**4.14±0.63**	**2.9-6.8 (4.17)**	***0.001****	**-0.19±0.29**	***0.892****
Magnesium	1.96±0.28	1.2-2.7 (1.9)	1.96±0.3	1.1-2.8 (1.95)	*0.972*	0±0.08	***0.962****
Sodium	140.39±5.94	112-155 (140)	141.07±4.48	127-154 (140)	*0.307*	-0.69±4.01	***0.738****
Phosphorus	**3.46±1.39**	**1.3-10.2 (3.3)**	**3.62±1.44**	**1.5-9.7 (3.4)**	***0.001****	**-0.16±0.35**	***0.969****
Total protein	**6.8±1.12**	**3.2-8.7 (7.1)**	**6.52±1.21**	**3.3-8.6 (6.75)**	***0.001****	**0.28±0.32**	***0.965****
Creatinin kinase,Total	172.31±224.82	4-1388 (96)	173.17±225.97	5-1427 (96.5)	*0.648*	-0.86±15.66	***0.998****
C-Reactive Protein	5.46±8.04	0-36.5 (2.31)	5.46±8.02	0-36.5 (2.57)	*0.883*	0±0.67	***0.997****
Urea	41.19±42.57	0.1-149 (33.5)	38.69±39.12	0.1-146 (33.5)	*0.768*	2.51±15.92	***0.927****
B-natriuretic peptide	1322.93±1193.82	261.1-3340 (832.55)	1325.03±1197.59	268.1-3347 (830.25)	*0.871*	-2.1±35.23	***1.000****
Troponin T	1.56±2	0.1-6.1 (0.77)	1.55±1.92	0.1-5.8 (0.79)	*0.499*	0.01±0.12	***0.999****
D-dimer	0.82±0.7	0.3-2.5 (0.56)	0.69±0.54	0.2-1.9 (0.51)	*0.036*	0.14±0.19	***0.990****

[a]Wilcoxon Signed Rank test *ICC: Intraclass Correlation Coefficients* **p<0.05*

ALT :alanine aminotransferase, AST: aspartate aminotransferase, BUN: blood nitrogen urea

3. Results and Discussion

3.1 Results

BD Barricor™ Tubes demonstrated clinically equivalent results for all analytes evaluated in this study when compared to BD SST™ II Advance Tubes. Chloride and sodium tests were found to have a good concordance and the other tests to have a strong level of concordance (Table 1).

Albumin, ALT, Amylase, AST, Bilirubin, Direct Bilirubin, Total BUN, Calcium, Chloride, Creatinine, Mg, Na, CK, C-RP, Urea, BNP, troponin T, D-dimer analysis was clinically equivalent for serum and plasma tubes, with no statistically significant difference.

The differences observed for Potassium and Total Protein are known to exist between plasma and serum and are not attributable to the BD Barricor™ Tube. Statistical differences are not clinically meaningful, thus all results are acceptable.

3.2 Discussion

The samples used in the laboratory are very diverse. The main ones; serum, plasma, whole blood, various fluids (pleural, pericardial), urine, and stool. Whole blood is non-separated blood to be serum or plasma. Serum is the remaining liquid part after the shaped elements (erythrocytes, leukocytes, platelets) are separated from the clotted blood. Plasma is the remaining liquid part after the shaped elements are separated from the blood, whose coagulation is inhibited by anticoagulants [7].

Which is the preferred sample type, serum or plasma? When comparing plasma and serum, there are advantages and disadvantages of both. Serum is the most commonly used material sample type for biochemical analysis in the clinical laboratory. Serum separation from whole blood requires a waiting time of at least 20-30 minutes for complete clotting [8].

The most important advantage of using plasma, especially in the emergency department or in places where rapid decision-making is needed, is to achieve results in a short time. Plasma samples can be directly centrifuged after collection, as opposed to serum from which clotting is complete after 30 minutes, and laboratory analysis can be performed immediately. It may be a life-saving advantage not to wait for clotting time under emergency conditions, intensive care or operating room conditions that compete over time.

In addition, the amount of plasma obtained from the same blood volume is 15 to 20% greater than the amount of serum; this allows more tests with less blood. This causes plasma to be preferred, especially in pediatric patients or in patients undergoing frequent blood tests [9]. Another advantage of plasma analysis is

that it minimizes the risk of hemolysis and reduces the possibility of false results [10].

Furthermore, interactions caused by clotting that occur when serum is obtained are not seen in plasma. Depending on the cellular metabolism and coagulation process, the concentration of glucose, total protein and platelets in the serum sample may decrease [11]. In our study, serum glucose and total protein were significantly lower than plasma samples.

The disadvantage of plasma to serum is that by the addition of anticoagulants, some analysis procedures may be affected or the concentration of components to be measured as a result of contamination with cations (NH4+, Li+, Na+, K+) may vary [10]. In our study, no significant difference was found in plasma and serum samples in Na analysis (p=0.307), whereas potassium level in plasma analysis was significantly lower than serum (p=0.001). Potassium and phosphorus increased in serum due to release from calls/platelets during clotting. And a linear correlation has been shown between platelet count and the increase in serum potassium. Clotting has not occurred in anticoagulated plasma samples. Thus plasma potassium and inorganic phosphorus levels present in vivo levels more accurately [11-14].

Another problem is that metals interact with EDTA and citrate by complexing. For example, inhibition of alkaline phosphatase activity by zinc binding or low measurement of calcium (ionized) by binding to heparin [15]. In our study, Ca levels were similar between plasma and serum (p=0.513).

EDTA affects the distribution of ions between intracellular and extracellular spaces due to citrate in its composition (eg Cl-, NH4 +) [16]. However, chloride levels were not affected in our study. In other words, whether the analysis was made from serum or plasma did not cause a significant difference in the results.

Our study in patients in the emergency department, anesthesia and reanimation, and coronary intensive care units showed that the results obtained by the analysis of plasma with fewer blood samples and yielding earlier results were not much different from the analysis with serum sample. Our results are consistent with the study of Sharma et al [9].

However, there are studies in the literature showing that significant differences can be observed when analyzing serum and plasma samples for the same biochemical parameters [17,18]. Considering the dates of these studies, the effect of the methods and devices used may have caused this difference. Not only device technology but also the development of tube technology (mechanical separator) is effective in reducing these differences. The mechanical separator plasma is superior to gel plasma, resulting in less cellular contamination resulting in longer stability and less false negative results [19-21].

In our study, we used BD Vacutainer® Barricor ™ (Becton Dickinson-USA) plasma tubes. Studies have shown that all analytes, except K and total protein, can be measured interchangeably in BD Rapid Serum Tubes and BD Barricor tubes applying the same reference ranges [22]. In another study, in a comparison using standard Vacutainer® lithium heparin tubes and BD Barricor tubes; It has been shown that there is a good correlation between the 2 tubes. The Barricor ™ tube has been shown to be an alternative to a regular lithium heparin tube [23]. Yet another study has shown that BD Barricor tubes can be an alternative to serum separator tubes in institutions aiming to reduce turnaround time [24].

As a result, Albumin ALT, Amylase, AST, Bilirubin, Direct Bilirubin, Total BUN, Calcium, Chloride, Creatinine, Mg, Na, CK, C-Reactive Protein, Urea, BNP, Troponin T, D- dimer results are similar in analysis in plasma or serum.

The low serum level of glucose from plasma may be due to the use of intracellular glucose during the time that serum is obtained. High levels of potassium and phosphorus in serum may also be due to intracellular potassium released in lysed cells and platelet metabolism during the waiting period [12-14,20].

4. Conclusions and Recommendations

We believe that plasma analyzers will be preferred more in line with the developing technology and needs. Plasma-based analysis may be preferred, especially in cases where the amount of time and sample is important such as emergency room, intensive care units and operating room, and where laboratory errors can cause fatal errors in diagnosis and treatment. Thus, more common serum problems such as coagulation or hemolysis, which cannot be detected visually but cause erroneous results, are avoided.

In addition, the use of plasma may reduce the workload of the laboratories, shorten the turnaroud time (TAT), increase the reliability of the results, as well as reduce the laboratory costs by causing serious reductions in the preanalytical error rate. Also the mechanical barrier in the Barricor™ tube is significantly more effective in separating cells from the plasma than the gel in the PST. Hence analytical changes are minimalized across the different storage time points and centrifugation settings.

5. Acknowledge

The authors have declared no conflicts of interest.

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