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Effect of Pneumatic Tube System Transport on Serum and Plasma Enzyme Levels

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Abstract

Pneumatic tube systems of various lengths are routinely used in many hospitals to transport blood collection tubes (serum, plasma, whole blood) to the testing laboratory. The present study evaluated the changes in the levels of enzymes in two different tube system transports within the hospital system. Two tubes of blood, one SST (Serum) tube and one Lithium Heparin (Plasma) tube, were collected simultaneously from 31 (Site 1) and 22 (Site 2) volunteers. Both tubes were hand carried to the lab and levels of LDH, AST, ALT, ALK PHOS, GGT and K were measured. These tubes were then hand-carried back to the site of collection and transported to the testing lab respective site pneumatic tube systems. The average carrier travel distance for Site 1 is 2911 feet and Site 2 is 1200 feet. Average travel speed of carriers at both locations is 28 feet per second. Both serum and plasma enzyme levels were measured using AU 680 and analyzer (Beckman Coulter Inc, Brea CA). Significant differences between plasma levels of LDH are observed when comparing the results of untubed blood vs. blood transported through pneumatic tube system. The length of travel of the tube has significant influence on various analytes and percent bias is high for ALT and AST at Site 1, but these differences are not statistically significant. On the other hand no significant differences are observed in serum levels of all enzymes. Hemolysis measured by Spectral index did not show any hemolysis of both serum and plasma tubes. Stability of plasma specimens are also decreased by 3 days when they are stored refrigerated. LDH levels are significantly elevated based on the length of tube travel in plasma and not in serum. Careful validation is needed when implementing plasma tubes for chemistry analytes, especially when transported through pneumatic tube systems.

1. Introduction

Pneumatic tube systems (PTS) of various lengths have been used routinely in many hospitals and medical centers. In these settings, it allows fast, safe and reliable transport of fresh whole blood specimens to the laboratory after the phlebotomy. PTS delivery costs less over time than employee couriers with significant decreases in turnaround times or setting up a satellite laboratory at various hospital locations [1].

Because it takes up to an hour for most whole blood specimens to clot in non-anticoagulated collection tubes, the majority of such specimens sent through a PTS will be unclotted or partially clotted when they arrive at the lab. However, sudden accelerations/ decelerations, air pressure changes, vibrations may affect the quality of the samples [2]. The mechanical disruption of red cells may result in hemolysis [3, 4, 5]. The disruption of white cells from leukemic patients may result in pseudohyperkalemia [6].

Poznanski et al [7] reported that whole blood allowed to clot, but not centrifuged, prior to PTS transport had increased lactate dehydrogenase activity following arrival at the laboratory compared to freshly drawn whole blood. The tubes used in the study did not contain a gel separator. Recently, Strubi-Vuillame et al [8] observed an overestimation of 18.8% mean bias using Lithium heparin tubes. The degree of hemolysis was significantly increased during PTS transport in plain non-anticoagulated whole blood compared to similar collection tubes that contained a gel separator [4]. These findings suggest that the gel protects against hemolysis by an undefined mechanism. No studies were found that compare the effect of PTS transport of centrifuged plasma and serum collected in gel tubes on chemistry tests. The present study evaluated the effect of PTS transport on centrifuged and not centrifuged serum and plasma on chemistry enzyme levels. Also evaluated the stability of the analytes stored refrigerated in primary gel tube as well aliquoted plasma after removing from primary tube.

2. Methods

2.1. Pneumatic Transport System

This study was conducted in two sites of our medical center. Site 1 (Biotech-1 campus) and Site 2 (Memorial Campus). They were chosen because to evaluate the effect of different lengths of PTS transport ((Swiss log Holding AG, Switzerland) on chemistry analytes reported. At Site #1 (Biotech-1), the average carrier travel distance is 2911 feet and for Site 2 (Memorial campus) is 1200 feet. Average speed of carriers at both locations is 28 feet per second. Eco seal Plastic carriers are used in both systems to transport specimens. The design is made to seal the contents in the carrier to eliminate the possibility of having a spill of improperly packaged items into the system piping. All these carriers have custom foam and plastic zip lock bag in each carrier and double bagged for transport.

2.2. Blood Collection and Transport

Two tubes of blood containers with gel, one serum (SST, serum separator tube) and Plasma (Lithium Heparin tube), were collected from 31 (Site 1) and 22 (Site 2) volunteers. Both tubes

were hand carried to the lab and levels of LDH, AST, ALT, ALK PHOS, GGT and K were measured. These tubes were then hand carried back to the site of collection and transported to the testing lab respective pneumatic tube systems.

In a second study conducted only at Site #1, another set of both plasma and serum gel tube whole blood samples (n=31) were transported through the PTS transport to compare with the above scenarios. All tubes in both cases are transported immediately (< 1 hour) after collection.

Both serum and plasma enzyme levels (Lactate Dehydrogenase (LDH), Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Alkaline Phosphatase (ALP), Gamma glutamyl transferase (GGT) and potassium (K) were measured at both sites using AU 680 analyzer (Beckman Coulter Inc, Brea CA)

2.3. Stability Studies

All Plasma samples were tested for stability for the refrigerated storage conditions. Some samples are stored and tested in the primary tubes (gel-centrifuged) and some of them are aliquoted to a different tube. Serum samples were tested in the same way many times and are good for 7 days (data not presented).

Result data was statistically analyzed using EP Evaluator, release 11.0 (D.) (Data Innovations, LLC). The two-tailed p value and statistical significance was calculated using graph pad software (<http://graphpad.com>).

3. Results

3.1. Effect of PTS Transport on Serum and Plasma Enzyme Levels

There were no differences between either serum or plasma levels of measured analytes (Table 1) when PTS was not used (Hand-Carried). Significant differences between serum and plasma levels of LDH are observed when unspun (not centrifuged at the site of collection) specimens are transported through PTS compared to samples not transported through PTS (Table 1). In addition, high mean bias was observed in plasma levels of AST, ALT and GGT levels but they are not statistically significant. K levels are not affected in either way of transport.

Table 1. Effect of Tube Site #1 (Biotech-1) transport on serum vs. plasma analytes.

Analyte	Serum Vs Plasma (Hand-Carried)		Serum Vs Plasma (Unspun and PTS transport)		Serum Vs Serum (Spun and PTS transport)		Plasma Vs Plasma (Spun and PTS transport)	
	Corr Coef (R)	% Mean Bias	Corr Coef (R)	% Mean Bias	Corr Coef (R)	% Mean Bias	Corr Coef (R)	% Mean Bias
LDH (IU/L)	0.87	9.8	0.56	60.9*	0.98	5.9	0.26	58.6*
AST (IU/L)	0.98	3.1	0.94	20.2	0.98	2.4	0.94	24.6*
ALT (IU/L)	0.98	1.1	0.99	11.7	0.98	2.4	0.92	14.3
GGT (IU/L)	0.99	-1.1	0.99	12.2	0.99	-0.2	0.99	10.8
ALP (IU/L)	0.99	-1.4	0.84	4.8	0.99	0.5	0.99	0.6
K (mmol/L)	0.77	-5.5	0.94	-0.5	0.96	0.5	0.96	0.07

1. R= Correlation Coefficient between Serum and plasma test values.

2. % Mean Bias was calculated using the differences in mean values all the test samples analyzed.

*Mean Bias was statistically significant (p<0.001)

Table 2. Effect of Tube Site #2 (Memorial Campus) transport on serum vs. plasma analytes.

Analyte	Serum Vs Plasma (Hand-Carried)		Serum Vs Serum (Spun and PTS transport)		Plasma Vs Plasma (Spun and PTS transport)	
	Corr Coef (R)	% Mean Bias	Corr Coef (R)	% Mean Bias	Corr Coef (R)	% Mean Bias
LDH (IU/L)	0.98	-3.0	0.98	6.8	0.62	42.0*
AST (IU/L)	0.99	-1.0	0.99	-0.2	0.99	8.9
ALT (IU/L)	0.99	-3.4	0.99	-0.3	1.00	2.2
GGT (IU/L)	0.99	-1.7	0.99	0.0	0.99	10.2
ALP (IU/L)	0.99	-2.4	0.99	0.1	0.99	2.3
K (mmol/L)	0.94	-7.4	0.99	1.0	0.99	2.0

1. R= Correlation Coefficient between Serum and plasma test values.

2. % Mean Bias was calculated using the differences in mean values all the test samples analyzed.

*Mean Bias was statistically significant (p<0.001)

Table 3. Stability of analytes in Plasma stored both in primary and aliquot tubes after separation.

Analyte	Primary tube			Aliquot tube		
	Day 1*	Day 2*	Day 3*	Day 1*	Day 2*	Day 3*
LDH (IU/L)	14.2	25.3	32.4	-2.7	-8.2	-14.0
AST (IU/L)	3.9	10.4	15.7	-0.2	-1.5	-0.3
ALT (IU/L)	1.2	8.3	8.7	0.6	7.1	7.4
K (mmol/L)	6.4	9.8	13.6	-0.8	0.4	0.8
Phosphorus (mg/dL)	4.6	11.2	15.1	0.3	1.7	0.0
Glucose (mg/dL)	-9.1	-19.9	-31.4	0.2	0.3	2.3

*Data presented as % mean increase or decrease in the analytes when compared to Day 0 of testing.

On the other hand, when blood container tubes are centrifuged at collection site and transported through PTS, significant differences were noted in plasma LDH and AST levels at site#1 (Table 1) and only LDH levels at Site #2 (Table 2). No significant differences observed between serum levels at both sites when they are spun and transported through PTS. Mean Percent bias is high for ALT, and GGT at both sites, but these differences are not statistically significant.

3.2. Stability of Analytes in Plasma

Stability of the analytes when stored in primary plasma (Lithium Heparin Gel) tubes are significantly decreased when compared to plasma samples stored in aliquot tubes. LDH, K, Phosphorus are significantly elevated and Glucose is significantly decreased by day 1. (Table 3). This is not observed in Serum tubes and they are stable for 7 days (data not shown).

4. Discussion

Pneumatic tube transport (PTS) systems allow convenient and rapid transport of blood specimens from the collection sites to clinical laboratories. Many major hospital systems use plasma collection tubes to allow rapid testing of the chemistry analytes, as the need to wait for the clot formation for serum tubes as not there before centrifugation [9]. PTS of various lengths are routinely used in many hospitals and there is a growing attention to quality of blood specimens and accurate test results. This was mainly due to rigorous roller-coaster type accelerations and decelerations tubes undergo during transport and can contribute to the preanalytical errors [10]. These physical forces during transport can lead to stress and rupture of erythrocytes and lymphocytes [11], leaking its

contents to plasma or serum. These rupture of membranes can cause hemolysis [12].

The present study evaluated two PTS transport systems of various lengths on both serum and plasma levels of enzymes and potassium levels. All the samples are compared to respective hand carried specimen test results. There are no measurable differences observed in the serum specimens between hand-carried or PTS at both sites in both spun and unspun samples are transported. Also, there are no differences observed between both plasma and serum specimens when samples are hand carried from the site of collection to the testing laboratory. However significantly higher differences are observed in plasma LDH levels compared to serum levels and higher mean bias observed in plasma AST, ALT and GGT levels. Hemolysis measured by Spectral index did not show any hemolysis of both serum and plasma tubes.

In the above analyses, whole blood was transported through PTS to the laboratory without centrifugation at the site of collection. To check if centrifugation before transport improves the accuracy of the test result, plasma and serum specimens are spun at the site of collection and transported via PTS at both sites. Serum specimens at both sites did not show significant differences, on the other hand statistically significant differences are observed in plasma specimens in both LDH and AST levels. ALT and GGT levels are also elevated in plasma specimens compared to hand-carried specimens. The impact of bias is lower at site 2 compared to site 1. This points out to the length of travel of the PTS transport has a major influence on the accuracy of test levels. LDH levels are significantly elevated based on the length of tube travel in plasma and not in serum. Similar observations are noted for LDH and K using PTS [13]. In our study, we did not observe significant differences in K and ALP levels. Careful validation is needed when implementing plasma

tubes for chemistry analytes, especially when transported through pneumatic tube systems.

In clinical laboratories it is expected to save tubes once testing is completed up to 7 days, to allow additional add-on testing without redrawing the patient. All serum specimens are validated for stability of measured analytes for serum specimens for 7 days. Similar analysis was conducted to evaluate stability for plasma specimens stored refrigerated after centrifugation. Stability of analytes in plasma (3 days) is significantly decreased when stored in primary tube. LDH, AST, ALT, K, Phosphorus are continuously elevated and glucose levels are decreased. Decrease in LDH levels are observed in samples separated in stored in aliquot tubes only.

5. Conclusions

LDH levels are significantly elevated based on the length of tube travel in plasma and not in serum. Even though statistically not significant, but higher bias observed in AST, ALT and GGT levels which require consideration. Stability of analytes in plasma is significantly decreased when stored in primary tube. This is not observed in serum tubes. Careful evaluations of stability are needed when clinical laboratories substitute plasma for serum samples.

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