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Effects of one directional pneumatic tube system on routine hematology and chemistry parameters; A validation study at a tertiary care hospital

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ABSTRACT

Background: The validation of sample stability through pneumatic tube system (PTS) is essential. The objective of this study was to evaluate the effects of PTS transportation on laboratory results.
Methods: Paired EDTA and SST blood samples were collected from 56 randomly selected patients. Laboratory parameters were compared between PTS group and hand-delivered group.
Results: No statistical differences were observed for complete blood counts, white blood cell differential parameters, erythrocyte sedimentation rate and most chemistry parameters between PTS and hand-delivered transport procedures. Mean platelet volume results obtained from samples transported through PTS were lower than that obtained from samples transported through hand-delivered method ($P = 0.001$). The results of aspartate aminotransferase ($P = 0.000$), lactate dehydrogenase ($P = 0.000$), and hemolysis index ($P = 0.000$) from PTS group were higher than that from hand-delivered group.
Conclusions: All laboratories should validate the stability of the results from samples according to transportation method.

1. Introduction

Preanalytical phase of clinical laboratory testing is the most vulnerable part to errors. This phase includes test ordering, collection of diagnostic specimens, handling, transportation, and storage of the specimen [1]. It has been demonstrated that the great majority of laboratory errors in the total test process come from this preanalytical phase [2]. Inappropriate sample transportations can fail to obtain a valid and fast laboratory test result.

Modern pneumatic tube system (PTS) provides rapid and efficient transportation of blood samples to the laboratory [3] and has been widely adopted. It is widely used to reduce the expanding workloads and to lead to faster sample processing and decreased turnaround times. During transportation, however, samples are often exposed to fast acceleration and deceleration [3]. It has been demonstrated that these changes can alter the quality of samples and induce hemolysis by leading primarily to increase in lactate dehydrogenase (LDH) concentrations, and potassium concentration [3–5]. It can also affect the results of in vitro platelet function test [6]. Incorrect test results can affect the diagnosis and the treatment for patients.

The effects of specimen transport when using a new PTS on laboratory results should be validated. The aim of this study was to evaluate the effects of one directional PTS on hematology and chemistry laboratory results in blood samples.

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2. Materials and methods

2.1. Subjects

Fifty-six pairs of samples for hematology analysis and chemistry analysis were included. Paired blood samples from each patient who underwent preoperative workup were randomly selected from specimen collection room without consideration of diagnosis from November 2016 to December 2016. The median age (range) was 48 (22–87) years. Female/male were 37/19. The collections of blood specimens were performed by well-trained phlebotomists. Samples were collected into 2 vacutainer K_2EDTA plastic tubes (Ref no. 367,856; BD Medical Systems, Franklin Lakes, NJ, USA) and into 2 vacutainer plastic serum tube (Ref no. 367,955; BD Medical Systems, Franklin Lakes, NJ, USA), from the same venipuncture. Laboratory parameters were measured using residual blood samples that would have been discarded. This study has obtained approval from the Institutional Review Board at Daegu Catholic University Medical Center (DCUMC).

2.2. Sample transportation

The PTS installed at DCUMC is a computer-controlled, one directional system of 2.5-cm diameter pipelines (Tempus600®, TIMEDICO A/S, Denmark). Sample tubes (1 in a K_2EDTA tube and 1 in a serum tube) were sent via the PTS. The corresponding sample tubes were hand-delivered by our laboratory personnel. The clinical laboratory is located on the fifth floor and the specimen collection room is located on the first floor at DCUMC. The distance of the PTS between 2 stations is approximately 347 ft (106 m). The system functions at a speed of 7–10 m/s and uses transfer stations that accelerate and decelerate the samples during zone transfers.

2.3. Laboratory parameters

All paired samples were treated in parallel, and analyzed at the same time to reduce the bias originated from time and temperature. Laboratory parameters routinely and frequently ordered were included.

The whole blood specimens anticoagulated with EDTA were analyzed for complete blood counts (CBCs), and white cell differentials using DxH800 (Beckman Coulter, Fullerton, CA, USA) and for erythrocyte sedimentation rate (ESR) using Test 1 (Alifax S.p.A., Polverara, Italy). The DxH800 uses impedence, light scatter and VCS technology in measuring red blood cells (RBCs), platelets (PLTs), white blood cells (WBCs) counts and parameters [7]. The CBC parameters consisted of WBCs, RBCs, hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), and platelets (PLTs). The WBC differential included the percentages of neutrophils, lymphocytes, monocytes, eosinophils, and basophils. The platelet parameters consisted of mean platelet volume (MPV), and platelet distribution width (PDW). The Test 1 uses photometrical technique to detect RBC aggregation for the measurement of ESR [7,8].

The serum samples were analyzed for aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), LDH, γ -glutamyl transferase (GGT), total bilirubin (T-bil), cholesterol, triglyceride (TG), glucose, protein, albumin, blood urea nitrogen (BUN), creatinine, uric acid, sodium (Na), potassium (K), chloride (Cl), lipemia index, icterus index and hemolysis index using cobas 8000 (Roche Diagnostics System, Basel, Switzerland). The quality control and calibration of all instruments were performed using proprietary controls and standard material.

2.4. Statistical analysis

Statistical analysis was performed using R software, version 3.2.4 (R Development Core Team 2016; http://www.R-project.org/). Continuous parameters with normal distribution are presented as mean with SD. Laboratory data with non-normal distribution are presented as median [interquartile range]. The statistical difference was represented by paired Student's *t*-test or Wilcoxon signed rank test. Statistical significance was considered if $P < 0.05$. Data were plotted using Bland-Altman plot to show difference pattern between the Tempus and hand-delivered method.

3. Results

Hematology parameters and chemistry parameters were obtained from samples sent to the laboratory by the PTS and hand-delivered method. The CBC and ESR results are shown in Table 1. No statistical differences were observed for CBC and ESR between PTS and hand-delivered transport procedures. There were no statistical differences for WBC differential parameters (Table 2). PLT parameters are shown in Table 3. MPV results between PTS and hand-delivered method showed statistical difference ($P = 0.001$). Mean difference between PTS and hand-delivered method were lower than zero for MPV (Fig. 1). The biggest difference in MPV was 2.4 fL. Bland-Altman plot showed that differences in measurements were within the 95% confidence interval of the mean difference except two outliers.

As shown in Table 4, median values of chemistry parameters were not significantly different except for AST ($P = 0.000$), LDH ($P = 0.000$), and hemolysis index ($P = 0.000$). Bland-Altman plots of these parameters are shown in Fig. 1. These plots showed that differences in measurements were within the 95% confidence interval of the mean difference except one to three outliers. Means of differences between PTS and hand-delivered method (represented by the solid bold line in Fig. 2) were systematically higher than