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Original Study

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Comparison between use courier transport with pneumatic tube system on the results of routine hematology test, Prothrombin Time (PPT), Activated Partial Thromboplastin Time (APTT), and potassium

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Abstract: Pneumatic tube system (PTS) is a transport medium that is widely used in hospitals. The samples transported via PTS would get vibrations due to changing air velocity and pressure. This unstable pressure could cause pre-analytic errors in laboratory measurements. It happened because it damages erythrocytes and lymphocytes and causes haemolysis. It has been demonstrated that these changes can alter the quality of samples and induce haemolysis by leading primarily to increase in lactate dehydrogenase (LDH) concentrations, and potassium concentration. Haemolysis is dined as the release of intracellular components of erythrocytes and other blood cells into the extracellular space of blood. It can also affect the results of in vitro platelet function test. Incorrect test results can affect the diagnosis and the treatment for patients Every hospital that uses PTS are advised to validate and investigate that PTS has the possibility of haemolysis and impacts laboratory results of blood specimens. The purpose of the study was to validate and know comparison between use courier transport with using PTS on the results of routine haematology tests, PPT, APTT, and potassium. This research was experimental research by using posttest without control. The research used statistical test which was paired t-test. The research was conducted at the Integrated Clinical Laboratory Installation of the Gadjah Mada University Academic Hospital in August – October 2020 with 30 preoperative patients. Data were analysed with Prism GraphPad 8 software. There was no significant difference between WBC, RBC, Hb, HCT, MCV, MCH, MCHC, PPT, and APTT. Moreover, there was a significant difference between the results of PLT and potassium in the samples transported via PTS and delivered by courier transport.

Keyword: APTT Evaluation; Pneumatic Tube System; Potassium; Routine Hematology

INTRODUCTION

Pneumatic tube system (PTS) is a transport medium that is widely used in hospitals. Delivery using PTS can help hospital services become faster and more efficient, especially for sending drugs, radiology results, tissue samples, and blood specimens from various units, both laboratory, radiology, pharmacy, and wards and poly services[1]. The use of PTS can reduce laboratory Turnaround Time (TAT). TAT is the period used for laboratory measurements starting from delivery, analysis up to the results come out[2]. During PTS transport, sample quality can be affected by the exposure to rapid acceleration, radial gravity forces, sudden decelerations, and other extreme temperature and physical forces. These violent forces may contribute to pre-analytical errors due to erythrocyte and lymphocyte rupture. A study by Weaver and colleagues compared the effects of PTS and manual transport on the results of 15 chemical tests and 6 hematologic

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procedures. The only difference they observed in PTS specimens was that the activity of lactate dehydrogenase exceeded the precision of the test. However, the remaining tests - serum sodium, potassium, chloride, carbon dioxide, total protein, albumin, calcium, glucose, creatinine, total bilirubin, alkaline phosphatase, aspartate transaminase, acid phosphatase, uric acid, leukocyte count, erythrocyte count, hemoglobin, hematocrit, prothrombin time (PT), and activated partial thromboplastin time (APTT) - were not affected by PTS[3].

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. Pneumatic tube system (PTS) provides rapid and efficient transportation of blood samples to the laboratory 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. 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[4]. Hemolysis is dined as the release of intracellular components of erythrocytes and other blood cells into the extracellular space of blood[5].It can also affect the results of in vitro platelet function test. Incorrect test results can affect the diagnosis and the treatment for patients[4].

PTS can cause small vibrations in the sample due to changes in air velocity and pressure during sample delivery. The unstable pressure can cause preanalytical errors in laboratory measurements. It is because it can damage erythrocytes and lymphocytes, causing hemolysis[6]. PTS's pressure and speed can increase potassium and Lactate Dehydrogenase (LDH) levels[7]. Sodi et al. emphasized that each laboratory should investigate the effects of the specific PTS used by the laboratory on the samples[5]. Every hospital that uses PTS are advised to validate PTS and investigate blood specimens for the possibility of hemolysis, activation of clotting factors that affect laboratory results[8].

MATERIAL AND METHOD

The research design was experimental research by using posttest without control[9]. The research was conducted at the Integrated Clinical Laboratory Installation of the Gadjah Mada University Academic Hospital in August – October 2020 with 30 preoperative patients. The sampling technique is purposive sampling. The criteria for the object of research were patients aged more than 18 years without comorbid diseases and not currently on blood-thinning drug therapy, and have a history of platelet disorders. Each research object was taken EDTA blood, citrate, and chemistry from two tubes each and then separated into two groups. The delivery of two groups of samples to the laboratory was conducted in two ways: Pneumatic Tube System and delivered by a delivery officer. Both groups of samples were processed for routine hematology tests, PPT, APTT, and laboratory measurements. The examination data was processed using the Paired t-test with the help of Prism GraphPad 8 software.

The research had been registered and obtained research ethics permit from the Health Research Ethics Commission of the Faculty of Medicine, Public Health and Nursing Universitas Gadjah Mada - Dr. Sardjito Hospital with registration number Ref.No. : KE/FK/1069/EC/2020.

RESULTS AND DISCUSSION

The research was conducted based on primary data from the routine hematological test. PTS and courier transport transported PPT, APTT, and potassium in September 2020.

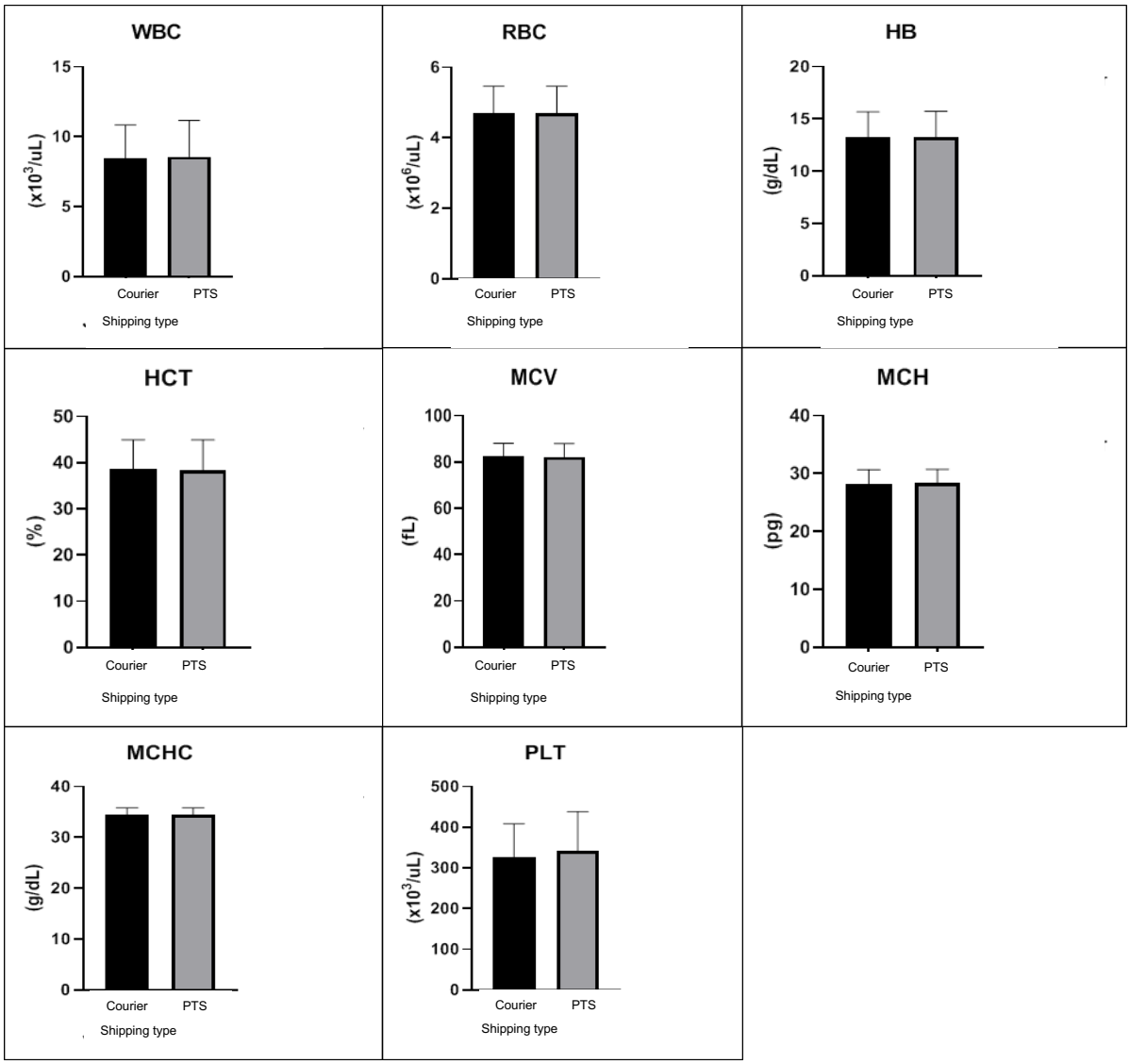

Figure 1. The comparison chart of Routine Hematology Test Results UsingSamples transported between by PTS and by Courier Transport

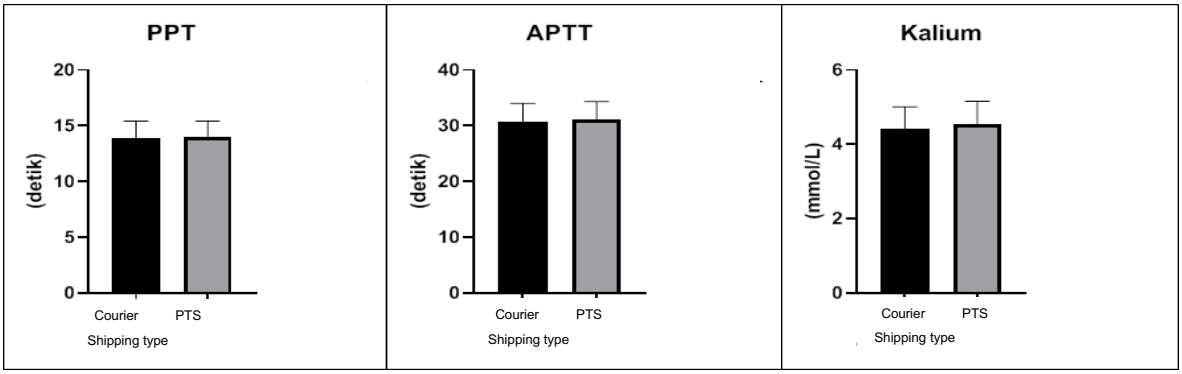

Figure 2. The comparison chart of PTT and APTT and Potassium Measurement Results Using Samples transported between by PTS and by Courier Transport)

The data was analyzed statistically by using paired t-test. The results were in the following:

Table 1. The Comparison of Hematology Test Results Transported between by

Parameter	*Mean*		*SD*		*P-value*
	Courier Transport	PTS	Courier Transport	PTS	
WBC	8.426	8.574	2.4099	2.6126	0.0556
RBC	4.687	4.687	0.7750	0.7733	0.9822
HB	13.24	13.28	2.4459	2.4585	0.1191
HCT	38.51	38.46	6.4492	6.4748	0.6857
MCV	82.28	82.17	5.8371	5.8237	0.1424
MCH	28.22	28.32	2.4502	2.4170	0.0896
MCHC	34.4	34.44	1.3736	1.3594	0.8007
PLT	326.1	340.9	82.4867	97.0115	0.0190

Based on table 1, the results of the PLT test between samples transported by PTS and by courier transport had significant differences with the SD difference is 32.64 and P-value 0.0190.

Table 2. The Comparison of PTT, APTT and Potassium Measurement Results Transported between by PTS and Courier Transport

Parameter	*Mean*		*SD*		*P-value*
	Courier Transport	PTS	Courier Transport	PTS	
PPT	13.85	14.02	1.5631	1.3895	0.4243
APTT	30.79	31.08	3.2293	3.2463	0.4212
Potassium	4.407	4.537	0.6047	0.6223	0.002

PTS is a transport medium that is being developed in hospitals. PTS is a fast and efficient automatic delivery system for sending drugs, patient medical record documents, X-Ray radiology results, tissue samples, and blood samples to laboratory units, pharmacies, wards, blood banks, and emergency units. The use of PTS can reduce waiting time for laboratory results and reduce manual labor. Reducing manual work can reduce the burden on workers and improve the quality of service to patients. However, PTS has a weakness as a transport medium for blood samples. Changes in velocity and pressure in the PTS vacuum system can cause the blood sample to be sent to hemolyze. Hemolysis is the disruption of the red blood cell membrane, which causes the release of hemoglobin and other intracellular components into the surrounding fluid. In vitro hemolysis caused by the use of PTS causes changes in the quality of specimens can affect the clinical laboratory measurements such as chemicals, especially potassium, lactate dehydrogenase (LDH), hematology, and coagulation parameters[8].

A routine hematology test was carried out using the Sysmex XP 100 tool. The Sysmex XP 100 tool is a tool used for routine hematology tests using the impedance method. This research's routine hematological tests consisted of some parameters such as WBC, RBC, HB, HCT, MCV, MCH, MCHC, and PLT. In this research, there were no significant differences between the results of WBC, RBC, HB, HCT, MCV, MCH, and MCHC in samples transported between by PTS and by courier transport. However, the results of the platelet (PLT) test showed a significant difference.

The use of PTS as a specimen transport medium did not have a negative impact[10]. The research conducted by Kurniawan et al. (2015) showed that delivery with PTS at Dr. Hospital. Wahidin Sudirohusodo did not affect the results of routine hematological tests when compared to transport by hand. The small vibrations that occurred during sample delivery could cause small changes in the lysis of blood and undetectable by direct sample observation. The distance and speed of samples travel also affect the incidence of hemolysis. It affects the results of routine hematological tests [11,12]. The results of this research were also in line with the research conducted by Quellec et al. (2017). The research stated no significant difference in the results of routine hematology transported between by PTS and by courier transporter. Another study also showed no statistically significant differences for CBC, reticulocyte count, and ESR transported by both methods [7]. Wallin et al. investigated the effects of PTS and manual transportation on routine hematology, coagulation, and platelet function with PFA-100, and they did not observe any differences in the results[13]. Another study also showed there were no statistically significant differences for CBC, WBC differential count, and ESR between both methods[14].

Pre-analytic factors strongly influenced the quality of the results of the hematology test. PTS was used to reduce waiting time for laboratory results. Thus, it could reduce pre-analytic errors due to delays in the tests between sampling and blood analysis. The waiting time for the results of laboratory tests between samples sent using PTS was shorter than the delivery by hand. The advantage of using PTS is that it can directly deliver blood samples after blood collection. At the same time, delivery by hand is usually done after collecting several samples so that there is storage and delay of sample processing[15].

Based on table 1, the results of the PLT test between samples transported by PTS and by courier transport had significant differences with the SD difference of 32.64. The results of this study are in line with research conducted by Subbarayan et al., where there was a significant difference between the results of the PLT sent by the PTS by courier transport. In this research, the p-value was <0.001, with an average difference of 0.135. Samples delivered PTS showed an increase in the number of PLT yields. The increase in PLT is due to pressure from PTS during delivery which causes PLT fragmentation[16].

The coagulation parameters test conducted in this research were PPT and APTT. The tool used in the research for coagulation test is the Stago Start.This research showed no significant difference between the results of the PPT and APTT test using samples transported between by PTS and by courier transport. This research is in line with Quellec *et al.* (2017), which reported that PPT results, Fibrinogen, PLT, and Factor VIII had no significant change between the samples transported PTS by courier transport. Kocak et al. (2012) also reported no significant difference in coagulation tests such as PPT and APTT between samples transported between by PTS and by courier transport. According to a study conducted by Handawi, there was no significant difference in the impact of using PTS and manual transportation by the courier transport for coagulation test. The clinical observations were also found to be insignificant. The PTS transport system does not cause activation of clotting factors in the PPT test, so it is safe for PPT test results[16]. The study by Enko et al. also stating that pneumatic transportation did not alter platelet function[17].

In this research, there was a significant difference in the potassium test results between samples transported by PTS and by courier transport. The tool used for the potassium test in the clinical pathology laboratory of UGM academic hospital was SmartLyte Plus. The serum used for potassium testing should not be hemolyzed.

PTS can cause hemolysis because of some aspects. There is the speed of delivery, the length of the system, acceleration or sudden deceleration of the system, changes in air pressure, and changes in the direction of motion of the PTS.

Hemolysis can cause false results on inspection LDH, potassium, and AST. Hemolyzed samples cannot be used for measurements and must use new samples, causing delayed laboratory results needed for diagnosis and treatment[18]. In this research, the hemolysis index level was not observed between samples transported by PTS and by courier transport but only observed by visual.

The significant differences in potassium results are possible because hemolysis micro is not perceivable by the eye. It was occurred due to delivery speed, system length, sudden acceleration or deceleration of the system, changes in air pressure, and changes in the direction of motion of the PTS causing micro hemolysis. In several types of research, the frequency of hemolysis in samples transported by PTS was 10.9% compared to 3.3% by manual labor, failure of the PTS system could also increase the frequency of hemolysis by 55%[19].

Different results were obtained by Cui et al., who reported that there was no difference between the potassium levels transported by PTS and by courier transport. On repeated deliveries with PTS, the potassium level increased slightly. Research by Kurniawan et al. shows no significant difference between samples transported by PTS and by courier transport[9]. LDH and K levels also were not significantly different in centrifuged samples transported by PTS and human carrier, regardless of rate and distance in the previous study[20].

The weakness in this research is that it is not known how the tool vendor sets much PTS speed. This research also did not evaluate the level of hemolysis of the sample. The waiting time for the test results from taking samples until the result comes out is also not counted. The effect of PTS on blood samples was not investigated at the location of other units delivered to the laboratory, such as the Arjuna ward, Yudistira, Nakula IGD, and Yudistira ER.

CONCLUSION

There were no significant differences in the measurement result of WBC, RBC, HB, HCT, MCV, MCH, MCHC, PPT, and APTT in this research. However, it was found that there were significant differences in the results of the PLT and Potassium test using samples transported by PTS and courier transport. The research can be continued by using PTS distance variations, PTS speed variations, and other laboratory examination parameters to evaluate PTS use. Measurements of platelet and potassium are not recommended with the use of PTS as a transport medium. Evaluation of the use of PTS as a delivery medium for Packed Red Cell (PRC) and Platelet Concentrate (TC) also needs to be conducted.

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AUTHOR'S CONTRIBUTION STATEMENT

Tri Novitasari and Norma Agustin Palupi prepared the samples, designed the protocols, executed the protocols. Kurnia Fitriasari and Tri Novitasari wrote the manuscript. Kurnia Fitriasari and Yoki Setyaji perform data processing and reviewed the manuscript. Yoki Setyaji supervised the manuscript. All authors have read and approved the final manuscript.

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DATA AVAILABILITY STATEMENT

The utilized data to contribute to this investigation are available from the corresponding author on reasonable request.

DISCLOSURE STATEMENT

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors. The data is the result of the author's research and has never been published in other journals.

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