

The Evaluation of Error Types and Turnaround Time of Preanalytical Phase in Biochemistry and Hematology Laboratories

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ABSTRACT

Background & objective: Each laboratory should determine the type of errors and turnaround time (TAT), especially in the preanalytical phase to report quality and timeliness of the test results. The current study aimed at investigating the common causes of preanalytical errors in biochemistry and hematology laboratories and evaluating the preanalytical TAT for outpatient samples.

Methods: Data of rejected samples in the laboratory information system from September 2014 to September 2015 were retrospectively reviewed. Also, the preanalytical TAT of the outpatient samples was evaluated over the period of three months from June to August 2015. Preanalytical TAT was calculated from order entry to barcode scanning in the autoanalyzer.

Results: With respect to the ratios of blood sample transfers, 1% of samples (2305 out of 225,563) in the hematology laboratory and 0.6% (1467 out of 255,943) in the biochemistry laboratory were rejected. The most common cause of rejection in the hematology and biochemistry laboratories was insufficient volume (48.8%) and hemolyzed sample (74.1%), respectively. The average preanalytical TAT for the outpatient samples was 62.3 minutes. The preanalytical TAT accounted for 10.8% (order entry-sample collection), 49% (sample collection-sample receipt), and 40.2% (sample receipt-barcode scanning in the autoanalyzer), respectively.

Conclusion: Of all the samples received in the biochemistry and hematology laboratories, the overall percentage of rejections were 0.6% and 1%, respectively. The main target to improve preanalytical TAT was determined as the transportation (sample collection-sample receipt) step.

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Introduction

Clinical laboratories play a key role in the diagnosis and treatment of patients since they provide data from the analysis of body fluids. Laboratory errors lead to a number of clinical problems including delayed diagnosis, additional laboratory testing, and incorrect diagnosis and treatment (1). Preanalytical phase errors account for approximately 60%-70% of laboratory errors. Major sources of preanalytical errors include inappropriate test request, patient preparation, specimen collection, specimen transportation, and specimen preparation for testing (2). Reduction of error rates in preanalytical phase is essential to ensure cost effectiveness, patient satisfaction, and quality laboratory service (3,4).

The turnaround time (TAT) used in hospitals to assay the performance of laboratory is defined as the time taken from order entry to result reporting (5). Shortening TAT is important for early diagnosis and treatment that shortens patients' hospital stay and consequently increases their satisfaction and safety (6,7).

The current study aimed at investigating (I) the causes and incidences of the specimens rejection in the preanalytical phase and (II) the preanalytical TAT of outpatient samples for quality and timeliness of reporting the test results.

Materials and Methods

The current study was conducted at the hematology and biochemistry laboratories of the Mustafa Kemal teaching Hospital. In the current study, the specimens rejected by the hematology and biochemistry laboratories from September 2014 to September 2015 were reviewed. The data were obtained from the laboratory information system (LIS). Furthermore, the preanalytical TAT of outpatient samples of chemistry, immunoassay, coagulation, and hematology test units were evaluated over a period of three months from June to August 2015. The preanalytical phase consists of order entry, barcode printing, sample collection, sample receipt, and barcode scanning in the autoanalyzer steps automatically recorded in LIS as five time points. The time intervals between the stages of preanalytical workflow (order entry-sample collection,

sample collection-sample receipt, and sample receipt-barcode scanning in the autoanalyzer) were calculated. The "sample receipt-barcode scanning in the autoanalyzer" step involves distribution of specimens to sections of the lab, centrifugation, and specimen loading.

In the outpatient clinics of the hospital, phlebotomy is usually performed by experienced staff using a vacutainer system. However, in the inpatient services, phlebotomy is mostly performed by nurses and interns using syringes and needles. The blood specimens are transported to the laboratory by the hospital personnel. Then, the specimens are assessed by experienced staff and either accepted or rejected depending on the rejection criteria of the hospital laboratories. The rejection criteria of the laboratory are clotted specimens, insufficient volume, excess volume, specimens with visible hemolysis, lipemic specimens, labelling errors, inappropriate tube, empty tube, and damaged specimens. The current study was approved by the Local Ethics Committee of Mustafa Kemal University.

Statistical analysis was conducted with Microsoft Excel 2010 program. Calculations of rejected specimens for hematology and biochemistry laboratories were presented as number and percentage. Data of preanalytical TAT were expressed as median (min-max).

Results

Table 1 lists the distribution of hematology and biochemistry samples rejected in the current study. Out of 225,563 samples received in hematology laboratory during the study period, 2305 samples (1%) were rejected. Out of 255,943 samples received in biochemistry laboratory during the study period, 1467 samples (0.6%) were rejected. In the hematology laboratory, the most common cause of rejection was insufficient volume (48.8% of total rejections) followed by clotted specimens (45.6% of total rejections). In the biochemistry laboratory, the most common cause of rejection was hemolyzed specimens (74.1% of total rejections) followed by insufficient volume (16.5% of total rejections). Of the specimens

rejected due to hemolysis, 66% were collected from the hospital inpatient services and 34% from the hospital outpatient clinics.

Table 2 shows the analysis of preanalytical TAT of outpatient specimens. The preanalytical TAT for

chemistry test units had a median of 62 minutes, immunoassay test units had a median of 73 minutes, coagulation test units had a median of 63 minutes, and hematology test units had a median of 51 minutes.

Table 1. Rejection analysis for hematology and biochemistry specimens

Rejection criteria	Biochemistry specimen rejection, frequency; n (%)	Hematology specimen rejection, frequency; n (%)
Clotted samples	32 (2.2)	1052 (45.6)
Insufficient samples	242 (16.5)	1124 (48.8)
Excessive amount	-	45 (2)
Hemolyzed samples	1087 (74.1)	24 (1)
Lipemic samples	46 (3.1)	3 (0.1)
Labelling errors	33 (2.2)	30 (1.3)
Any other reasons ^a	27 (1.8)	27 (1.2)
Total Rejection (n)	1467	2305
Total sample (n)	255, 943	225, 563
Total rejection rate (%)^b	0.6	1

a: Inappropriate tube, empty tube and damaged specimens.

Percentages: (Number of rejected samples/Total number of rejected samples) x100.

b: (The total number of rejected samples/ total number of samples for each laboratory) x100.

Table 2. Analysis of preanalytical TAT of outpatient specimens

Laboratory test groups	Order entry-Sample collection	Sample collection-Sample receipt	Sample receipt-Barcode scanning in the autoanalyzer	Preanalytical TAT (minutes)
Chemistry (n: 15,097)	7 (1-335)	26 (4-276)	29 (11-505)	62
Immunoassay (n:7,248)	8 (1-224)	29 (4-236)	36 (11-382)	73
Coagulation (n:3,094)	6 (1-233)	35 (4-213)	22 (11-299)	63
Hematology (n:10,538)	6 (1-335)	32 (4-276)	13 (5-289)	51
Average	6.75	30.5	25	62.3
% of each stage	10.8%	49%	40.2%	100%

The data were expressed as median (min-max), n: Number of blood samples. Chemistry test units: 30 tests like metabolites, electrolytes, enzymes, lipid profile etc.; immunoassay test units: 27 tests like thyroid function tests, vitamins, fertility hormones, tumor markers etc.; coagulation test units: 5 tests like prothrombine time, partial thromboplastin time, fibrinogen, etc.; hematology test units: 22 tests like hemoglobin, hematocrit, red blood cell count, platelet count, white blood cell count etc.

Table 3. Types of preanalytical errors in the previous studies*

Guimaraes et al. (9)	Sinici Lay et al. (10)	Goswami et al. (11)	Jacobsz et al. (12)	Bhat et al. (13)
Clotted	Clotted	Hemolyzed	Clotted	Clotted
Insufficient	Insufficient	Insufficient	Insufficient	Labeling errors
Hemolyzed	Inappropriate tube/container	Illegible hand writing	Labelling errors	hemolyzed

*Types of preanalytical errors are written in order of frequency.

Discussion

The reported incidence of the specimens rejected by biochemistry and hematology laboratories ranged 0.3% to 2.7% (8-10). Similarly, in the current study, the incidence of the specimens rejected by the biochemistry and hematology laboratories were 0.6% and 1%, respectively. Table 3 summarizes comparative data regarding types of preanalytical errors in the previous studies (9-13).

In the current study, insufficient volume (48.8%) was the most common factor leading to specimen rejection in the hematology laboratory and the second common factor in the biochemistry laboratory (45.6%). Similarly, this factor was the second common cause of specimen rejection in several studies (9-12). Literature shows that the incidence of insufficient volume is remarkably high in pediatric, neonatal, and oncology wards, in which peripheral vascular access is difficult (14,15). Chawla et al., found that the number of specimens with insufficient volume was higher in the outpatient clinics than inpatient services. The authors suggested that this difference could be attributed to the fact that the phlebotomists working in the blood collection areas perform incorrect phlebotomy practices due to a heavy workload (16). High rates of insufficient volume in the current study could be attributed to the fact that phlebotomy is mostly performed with syringes and needles in the inpatient services of the hospital. This can be due to the point that appropriate and sufficient amount of blood cannot be transferred to specimen collection tubes via syringes and needles, particularly to tubes with anticoagulants.

Clotted specimen was the second most common factor leading to specimen rejection in the hematology laboratory (45.6%). In some studies, this factor is the most common factor with an incidence ranging 43.8% to 55.8% (9,10,13). Inappropriate handling and pretreatment of blood samples after collection (e.g., poor mixing, keeping at horizontal position) is the main reason of the aforesaid clotting problem (17). In accordance with Clinical Laboratory Standards Institute (CLSI) guidelines, it is advised that all blood samples collected in vacuum tubes be mixed gen-

tly several times (18). It is believed that paying no attention to this procedure increases the incidence of clotted specimens.

Goswami et al., reported that hemolyzed specimens (81% of total rejections) was the most common cause leading to specimen rejection (11). In the current study, similarly, hemolyzed specimen was the most common cause of rejection in the biochemistry laboratory (74.1%). Hemolysis may be caused by a number of conditions including forceful evacuation of a syringe into a tube, prolonged tourniquet application, vigorous mixing of the blood collected into the tube, and the use of inappropriate needles (19). Dorotic et al., found in a questionnaire study that nurses had insufficient knowledge about the reasons of hemolysis (20). The frequency of hemolysis was more in inpatient services than outpatient clinics, similar to the results of the study by Chawla et al. (16). A higher incidence of hemolysis in inpatient services may be due to incorrect phlebotomy techniques and not using vacutainer system for blood collection. Samples in the inpatient services are mostly collected using syringes and needles. One study reported that the phlebotomy technique used for blood collection had a significant effect on the incidence of hemolysis (21). Another study reported that the incidence of preanalytical errors decreased from 61% to 48% after using vacutainer system (22).

It is important to reduce turnaround time for early diagnosis and treatment by providing the safety and pleasure of patients. In the current study, preanalytical TAT of outpatient samples was 62.3 minutes and increased preanalytical TAT was primarily due to delayed transportation of samples to the laboratory. Similarly, Kaur et al., found the TAT of preanalytical phase as 50.4±11.9 minutes in outpatient department and promotion of sample transportation resulted in prolonged preanalytical TAT (23). In another study, the time taken to preanalytical phase for outpatient chemistry specimens was 29.7±6.9 minutes and that was 68.1% of overall TAT. Additionally, lagging in phlebotomy was the main factor of extended preanalytical stage (24). Delays in transport may result from

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