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PRE-ANALYTICAL ERRORS IN CLINICAL CHEMISTRY LABORATORY OF A TERTIARY CARE HOSPITAL

Biochemistry

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ABSTRACT

Background: Sample testing in laboratory requires skills where errors can occur at any stage, i.e., pre-analytical, analytical and post-analytical phase. This leads to a misdiagnosis or mismanagement and represent a serious hazard for patient health. Current evidences demonstrate that the pre-analytical phase testing process is more error-prone than other phases. Present study focuses on the pre-analytical phase, with the aim to calculate rate of these errors at tertiary care hospital.

Methods: The samples received for clinical chemistry were 33679 in a duration of 6 months. Samples were screened for errors in three phases of laboratory testing (pre-analytical, analytical and post-analytical). Out of three phase, data on specimen and handling variables of pre-analytical errors was collected. Only routine clinical chemistry samples data after considering exclusion criteria was included in study.

Result: The total number of samples that were having pre-analytical errors were 354 which was greater than other types of errors. Hemolysis (10.7%) and lipemia (12.4%) contributed to major part of sample rejection in samples with pre-analytical errors. Hemolysis and lipemia had positive correlation with derangements in results of samples with errors ($p<0.05$). Information available with sample like request form details, clinical information, etc. was also correlated to erroneous samples.

Conclusion: The present study shows that there is definite correlation between pre-analytical errors and erroneous laboratory results. There is urgent need to control this phase of laboratory testing process. Adoption of suitable strategies for prevention can overcome this situation. Enrolling for various accreditation programmes by laboratories can minimize these errors.

KEYWORDS

Pre-analytical Errors, Quality Control, Laboratory Diagnosis

INTRODUCTION:

Many important clinical decisions on admission, treatment and discharge depend upon results of various laboratory tests done, making them of utmost importance with high degree of influence and compelling laboratory medicine to set higher quality standards.[1] Laboratory medicine has unique advantage by following regular statistical quality control (QC) activities and are leaps and bounds ahead of other clinical disciplines in introducing quality improvement initiatives. The process of diagnostic laboratory testing is broadly divided into three phases: pre-analytical, analytical and post-analytical phase.[2,3] Accurate laboratory outcomes are essential for the medical diagnosis and patient care because errors occurring at any of the phases may lead to wrong diagnosis and thereby causing serious impact on overall health of the patient. Automation and computers have greatly simplified many aspects of laboratory tasks and significantly decreased the analytical error rate.[4] Regardless of advanced automation in diagnostic laboratories; still extra-analytical phase is the chief source of errors which leads to unpredictable and unfavourable outcomes of laboratory results. Various studies have reported that 46-68% of laboratory errors occur in pre-analytical phase.[5,6] The pre-analytical phase involves all the steps from laboratory test request by a physician up to beginning of specimen analysis. Though being crucial, it is difficult to regulate and monitor this phase due to the involvement of too many medical professionals.[7] The International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) Working Group for Laboratory Errors and Patient Safety (WG-LEPS) has prepared the range of pre-analytical phase quality markers to underscore pre-analytical errors.[8] The pre-analytical phase error variables can be categorised into patient variables, collection variables and handling variables (Table-1).[9]

The present study is specifically focused on the collection and handling errors with aim to analyse rate of these errors and correlation of these variables with the derangements in results detected through repeat sample analysis bringing improvement in sample collection and handling procedure.

Table-1: Pre-analytical Variables

Patient Variables	Diet, Body Mass, Age, Medications, Gender, Smoking, Pregnancy, Exercise, Race, Dehydration
Collection Variables	Posture, Diurnal variation, Time of collection, Fasting status, Tourniquet, Presence of IVs, Capillary or Venous, Anticoagulants, Order of draw
Handling Variables	Hemolysis, Lipemia, Centrifugation, Processing time, Temperature, Sunlight, Evaporation, Aliquoting, Labelling, Transport conditions

METHODS:

The present study was conducted in clinical chemistry section of central clinical laboratory in a tertiary care hospital affiliated to S.B.K.S. Medical Institute & Research Centre without direct interaction with patients. Samples received during January 2013 to June 2013 were screened as per the standard guidelines for pre-analytical errors. Phlebotomies were performed by clinical department support staff and laboratory personnel. Samples received for routine clinical chemistry analysis (Clot activator/plain and $NaF+K_2C_2O_4$ anticoagulant) were screened for pre-analytical errors. Samples received for other investigations were excluded. Rejection of samples were done according to standard operating procedures of laboratory by laboratory staff upon receipt of samples and were duly noted in Laboratory Error Report sheet. The biochemical investigations were done for repeat samples as well as rejected samples to analyse derangements if any. Analysis was done on clinical chemistry auto-analyser "EM-200 (ERBA Mannheim)", electrolyte analyser "Easylyte (Medica Corp.)" as per standard operating procedures and analytes were measured by International Federation of Clinical Chemistry (IFCC) approved commercially available kits. Laboratory regularly runs internal quality controls and takes part in external quality assurance programmes. Frequency and types of pre-analytical errors (collection and handling variables) in clinical chemistry samples were categorised from Laboratory Error Report sheet as per prefixed criteria as shown below.

- Sample collection locations (IPD, OPD or Emergency)
- Posture of patient during collection
- Anticoagulants used
- Adequacy of sample volume
- Request form details (patient information and clinical information)
- Sample labelling
- Hemolysis
- Lipemia

Sample inclusion procedure is shown in Figure-1.

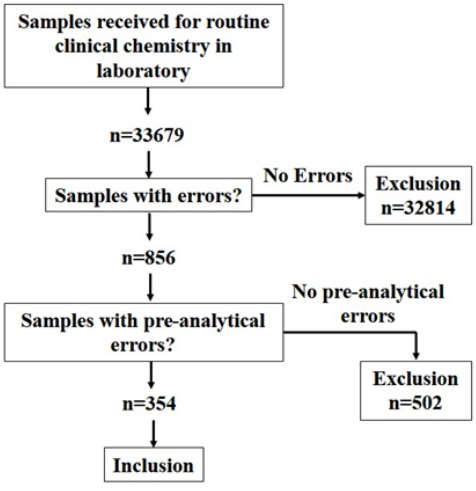

Figure-1: Sample inclusion

Data obtained was analysed using SPSS v20. Categorical variables were analysed using chi-square test. P-value of < 0.05 was considered to be statistically significant.

RESULTS:

The total number of samples screened in a duration of 6 months were 33679, out of which errors were reported in 856 (2.54%) samples. The pre-analytical errors were found in 354 (41.36%) samples out of total errors. It was found that highest pre-analytical errors were at the beginning of the week and frequency of errors decreased towards the end of the week (Figure-2).

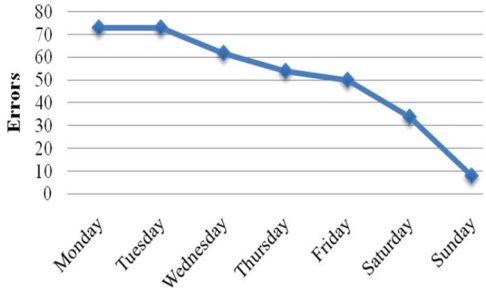

Figure-2: Day wise incidence of pre-analytical errors (n=354)

Among all pre-analytical errors found in study 62.1% were from In-patient departments (IPD) followed by emergency and Out-patient departments (OPD) with 26% and 11.9% errors respectively. The pre-analytical error in samples with clot activator/plain tubes was 82.8% and 11.9% samples were having inadequate sample volume for analysis as per laboratory criteria. 88.4% pre-analytical errors were detected when samples were collected form patient in supine posture. 49.9% of pre-analytical errors were related to improper patient information. There was labelling mismatch in 7.3% of samples. Hemolysis accounted for 10.7% of all pre-analytical errors and lipemia was found in 12.4% samples respectively (Table-2). Study found that IPD samples had more frequency of hemolysis than OPD (8.47% vs. 2.26% of pre-analytical errors).

Analysis showed that around 28% samples with pre-analytical errors were having derangements in their results when compared to previous reports and/or repeat sample reports (Figure-3).

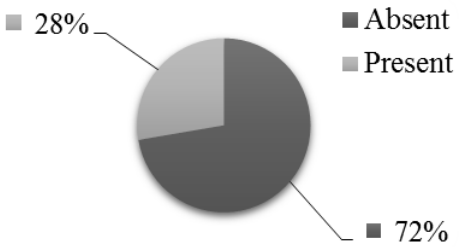

Figure-3: Derangements in samples with pre-analytical errors (n=354)

Derangements found in samples with pre-analytical errors from Emergency, IPD and OPD were 29.3%, 27.7% and 23.8% respectively and difference was found to be statistically insignificant. There was statistically significant difference in pre-analytical error samples with derangements with regards to sample volume adequacy. Request form details with various categories were found to have statistically significant difference in samples with derangements among pre-analytical errors. Hemolysis was directly correlated with derangements in samples with pre-analytical errors showing high degree of statistically significant difference (Figure-4). Lipemia was also found to be having significant correlation with derangement in results of pre-analytical error samples (Table-2).

Table-2: Correlation of derangements in various pre-analytical variables

	Prefixed Criteria	Preanalytical Errors (n=354)	Derangements in Results (n=98)	$\chi 2$	p-value
Collection Variables	**Timings**				
	IPD (12:00AM to 5:00PM)	220(62.1%)	61(27.7%)	0.442	0.802
	OPD (9:00AM to 5:00PM)	42(11.9%)	10(23.8%)		
	Emergency (5:00PM to 12:00AM)	92(26.0%)	27(29.3%)		
	Anticoagulants				
	Clot Activator/Plain	293(82.8%)	84(28.7%)	0.564	**0.453**
	$NaF+K_2C_2O_4$	61(17.2%)	14(23%)		
	Sample Volume				
	Adequate	312(88.1%)	93(29.8%)	5.066	**0.024**
	Inadequate	42(11.9%)	05(11.9%)		
	Posture				
	Supine	313(88.4%)	88(28.1%)	0.0996	**0.752**
	Sitting	41(11.6%)	10(24.4%)		
Handling Variables	**Information**				
	Complete Information	181(51.1%)	71(39.2%)	25.642	**<0.001**
	Age, Sex, ID Not Present	51(14.4%)	08(15.7%)		
	Clinical Information Not Available	42(11.9%)	05(11.9%)		
	Test Request Form Missing	64(18.1%)	10(15.6%)		
	Two or More Parameters Missing	16(4.5%)	04(25%)		
	Labelling Mismatch				
	Absent	328(92.7%)	93(28.4%)	0.598	**0.439**
	Present	26(7.3%)	05(19.2%)		
	Hemolysis				
	Absent	316(89.3%)	62(19.6%)	91.889	**<0.001**
	Present	38(10.7%)	36(94.7%)		
	Lipemia				
	Absent	310(87.6%)	65(21%)	53.523	**<0.001**
	Present	44(12.4%)	33(75%)		

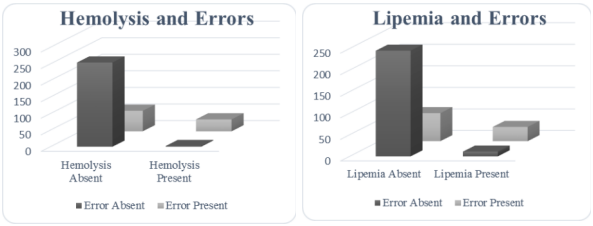

Figure-4: Hemolysis and lipemia correlation with derangements (n=354)

DISCUSSION:

There is significant reduction in laboratory errors in last few years due to advances in science and technology with regards to laboratory medicine automation ensuring accuracy and speed in analytical phase. The laboratory medicine being dependent branch, achieving accuracy in analytical phase only will not suffice, rather pre-analytical and post-analytical phases are equally important.[10] This study had error distribution rate of 41.36% in pre-analytical phase among total errors detected which is in corroboration with the results of other studies.[5,6,11,12]

It is evident from the observations of studies that there is significant role of medical and paramedical professionals in causation of pre-analytical errors requiring their cooperation as key to improve laboratory results quality.[13]

Some pre-analytical errors of concern noticed in present study were that the age, sex or identification were not mentioned in 14.4% samples; provisional diagnosis was missing in 11.9% samples; test request forms were missing in 18.1% samples (Table-2). Importance of such data is paramount as they help in correct interpretation of results. Reference range for various tests varies depending on age and sex. Clinical information regarding patient condition is crucial to avoid dispatch of incompatible results and also helps in correlating critical results.[14] Studies have shown that incomplete and missing details or manually completed forms can lead to improper interpretation and erroneous results.[15,16]

In this study, among samples with pre-analytical errors where derangement in results was detected, hemolysis was present in almost 95%. The sample may be hemolysed due to in-vitro processes like incorrect method of sample collection or transport though chances of in-vivo hemolysis can be there in certain conditions.[17] One study has showed that there can be considerable variation in results if hemolysed samples are processed.[18] IPD samples having more frequency of hemolysis than OPD in present study can be attributed to improper phlebotomy procedure followed by clinical support staff.[19] A study has found that proper phlebotomy training can reduce pre-analytical error rate by 2-4 times.[20]

This study found that 75% of all lipemic samples were having derangements in results which can be due to sample collection after heavy meals or the presence of some metabolic disorder.[21] Lipemia may arise due to to non-provision of information regarding prior preparation to the patients by the staff as well as non-compliance and/or misunderstanding of preparation rules by the patients as shown in studies that concluded that lipemia has clinically significant interference in majority of analytes.[22,23] Studies have showed that using ultracentrifugation process to clear lipemia in samples can greatly reduce derangements in laboratory results.[22,24]

All findings support that pre-analytical errors can have deteriorating effect on quality of laboratory. The limitation in present study is that patient related pre-analytical variables were excluded. A larger scale study that encompasses all pre-analytical variables can help in better understanding of their effects on quality of a laboratory results.

CONCLUSION:

There was definitive correlation between various pre-analytical variables with derangements in results in present study. Through this study we can say that implementation of total quality management (TQM) process becomes necessary to bring improvement in laboratory results. To conclude, we would like to state that one need to adopt a holistic approach toward laboratory diagnosis and function in concert with the clinicians to provide accurate results. Utilization of new accreditation standards which describe the adoption of suitable strategies for pre-analytical error prevention and control with enhanced communication among the health care providers would definitely enhance the reliability and accuracy of the laboratory.

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